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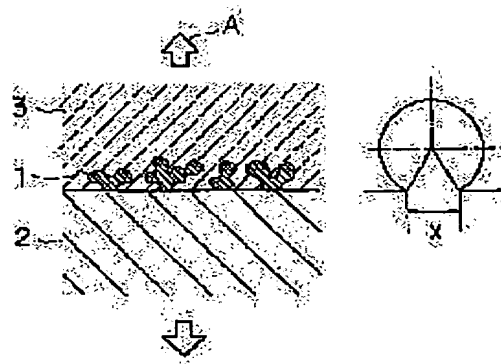
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(54) CLAD METAL MATERIAL, PRODUCTION METHOD AND CONTAINER FOR ELECTROMAGNETIC COOKING

(57)Abstract:

PURPOSE: To provide the clad metal material, which is sufficiently/closely adhered with each other different kinds of metal materials having different deforming resistance, etc., improving joining strength, further, to provide the container for electromagnetic cooking, which is improved for thermal efficiency and reliability.

CONSTITUTION: In the clad metal material, in which two kinds of metal materials of a magnetic metal 2 and high heat conductivity metal material 3 is laminated, a porous intermediate layer 1, which is laminated/stuck on one of metal material, is provided between two kinds of metal materials, it is the clad metal material that a part of the other metal material 3 is impregnated in the porous intermediate layer 1. Or, it is the clad metal material that constitutional gradient layer is provide as an intermediate layer between a magnetic metal material 2 and high heat conductivity metal material 3. A container for electromagnetic cooking is constituted of a clad metal material at least for the bottom part of container.

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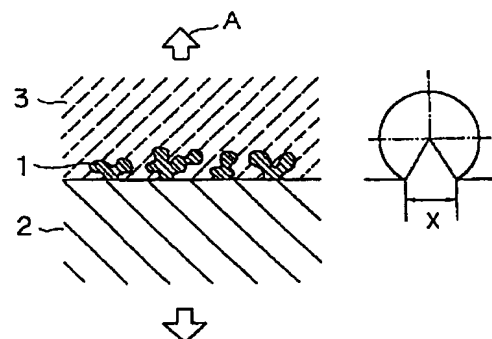
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(54) 【発明の名称】 複合金属材料とその製造方法、およびそれを用いた電磁調理器用容器

(57) 【要約】

【目的】 変形抵抗等が異なる異種の金属材料間を十分に密着させ、かつ接合強度の向上を図った複合金属材料、さらには熱効率や信頼性の向上を図った電磁調理器用容器を提供する。

【構成】 磁性金属材料2と高熱伝導性金属材料3というような2種の金属材料を積層した複合金属材料であって、2種の金属材料間に一方の金属材料2に積層固着された多孔性中間層1を設け、他方の金属材料3の一部を多孔性中間層1内に含浸させた複合金属材料である。あるいは、磁性金属材料と高熱伝導性金属材料との中間層として、組成傾斜層を設けた複合金属材料である。電磁調理器用容器は、少なくとも容器底部を上記複合金属材料で構成したものである。



【特許請求の範囲】

【請求項 1】 異なる 2種の金属材料を積層した複合金属材料であって、前記 2種の金属材料間に、一方の前記金属材料に積層固着された多孔性中間層を具備し、他方の前記金属材料の一部が前記中間層内に含有されていることを特徴とする複合金属材料。

【請求項 2】 請求項 1 記載の複合金属材料において、前記異なる 2種の金属材料のうち、一方は磁性材料であり、かつ他方は高熱伝導性材料であることを特徴とする複合金属材料。

【請求項 3】 請求項 1 または請求項 2 記載の複合金属材料において、前記多孔性中間層は、前記一方の金属材料と親和性を有する材料の接合層であることを特徴とする複合金属材料。

【請求項 4】 請求項 1 または請求項 2 記載の複合金属材料において、前記多孔性中間層は、前記一方の金属材料と親和性を有する材料の溶射層であることを特徴とする複合金属材料。

【請求項 5】 請求項 1 または請求項 2 記載の複合金属材料において、前記多孔性中間層は、前記一方の金属材料と親和性を有する材料の電気化学的成膜層であることを特徴とする複合金属材料。

【請求項 6】 請求項 1 または請求項 2 記載の複合金属材料において、前記多孔性中間層はその体積率が傾斜されており、かつ前記他方の金属材料は前記多孔性中間層の体積傾斜に応じて含有されていることを特徴とする複合金属材料。

【請求項 7】 異なる 2種の金属材料を積層した複合金属材料を製造するにあたり、一方の前記金属材料上に、該金属材料と少なくとも親和性を有する材料を接合して多孔性中間層を形成する工程と、他方の前記金属材料を前記多孔性中間層内に含浸しつつ、前記他方の金属材料を前記一方の金属材料に積層する工程とを有することを特徴とする複合金属材料の製造方法。

【請求項 8】 異なる 2種の金属材料を積層した複合金属材料を製造するにあたり、一方の前記金属材料上に、該金属材料と少なくとも親和性を有する材料を溶射して多孔性中間層を形成する工程と、他方の前記金属材料を前記多孔性中間層内に含浸しつつ、前記他方の金属材料を前記一方の金属材料に積層する工程とを有することを特徴とする複合金属材料の製造方法。

【請求項 9】 異なる 2種の金属材料を積層した複合金属材料を製造するにあたり、

一方の前記金属材料上に、該金属材料と少なくとも親和性を有する材料を電気化学的成膜して多孔性中間層を形成する工程と、

他方の前記金属材料を前記多孔性中間層内に含浸しつつ、前記他方の金属材料を前記一方の金属材料に積層する工程とを有することを特徴とする複合金属材料の製造方法。

【請求項 10】 請求項 7、請求項 8 または請求項 9 記載の複合金属材料の製造方法において、前記多孔性中間層内に、前記他方の金属材料の溶湯を含浸させることを特徴とする複合金属材料の製造方法。

【請求項 11】 請求項 7、請求項 8 または請求項 9 記載の複合金属材料の製造方法において、前記多孔性中間層内に、前記他方の金属材料の粉末を充填した後に加熱して含浸させることを特徴とする複合金属材料の製造方法。

【請求項 12】 磁性金属材料と高熱伝導性金属材料とを積層した複合金属材料であって、前記磁性金属材料と高熱伝導性金属材料間に中間層として組成傾斜層が設けられていることを特徴とする複合金属材料。

【請求項 13】 請求項 12 記載の複合金属材料において、前記組成傾斜層は、前記磁性金属材料と高熱伝導性金属材料との混合層からなり、前記混合層中の体積比率が傾斜されていることを特徴とする複合金属材料。

【請求項 14】 請求項 12 記載の複合金属材料において、前記組成傾斜層は、前記磁性金属材料、高熱伝導性金属材料およびセラミックス補助材の混合層からなり、前記混合層中の少なくとも前記磁性金属材料とセラミックス補助材との体積比率が傾斜されていることを特徴とする複合金属材料。

【請求項 15】 磁性金属材料と高熱伝導性金属材料とを積層した複合金属材料を製造するにあたり、前記磁性金属材料またはその予備成形体上に、少なくとも前記磁性金属材料を含む多孔層を形成する工程と、前記高熱伝導性金属材料を前記多孔層内に含浸して、前記磁性金属材料と高熱伝導性金属材料との組成傾斜層を形成しつつ、前記高熱伝導性金属材料を前記磁性金属材料に積層する工程とを有することを特徴とする複合金属材料の製造方法。

【請求項 16】 少なくとも底部が、請求項 2 記載の複合金属材料からなることを特徴とする電磁調理器用容器。

【請求項 17】 少なくとも底部が、請求項 12 記載の複合金属材料からなることを特徴とする電磁調理器用容器。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 本発明は、2種の金属材料を積層

した複合金属材料とその製造方法、およびそれを用いた電磁調理器用容器に関する。

【0002】

【従来の技術】近年、高齢化社会の到来や住宅の高層化等を背景として、安全性の点から電磁調理器が注目されている。電磁調理器用容器の構成材料としては、アルミニウムやその合金のような熱伝導性に優れた金属材料と、電磁加熱特性に優れた鉄やステンレス等の磁性金属材料とを、クラッド法等により積層接合した複合材料を用いることが検討されている。すなわち、電磁波により磁性金属材料に誘起された熱を、軽量でかつ熱伝導性に優れたアルミニウムやその合金により、被調理材料に有効に伝えようとするものである。

【0003】従来の電磁調理器用容器の具体的な作製方法について説明すると、例えば特開平3-4440号公報には、アルミニウムやその合金と磁性金属材料とをロール圧延によりクラッドし、このクラッド材に深絞り等のプレス成形加工を施して容器形状としたものを使用することが記載されている。しかし、このようなクラッド材は、アルミニウムやその合金と磁性金属材料との変形抵抗が大きく異なるために、圧延接合時に蛇行したり、しわが生じる等、加工性に大きな問題を有していた。また、上記クラッド材を深絞り等のプレス成形加工して容器形状とする際に、上述した変形抵抗が大きく異なることに起因して、接合界面で剥離が生じやすいという欠点があり、これにより電磁調理器用容器の熱効率を大きく低下させてしまうという問題があった。

【0004】また、例えば特開平5-116244号公報には、アルミニウムやその合金と磁性金属材料とを熱間等方向加圧法により接合し、この複合材をプレス成形加工して容器形状としたものを使用することが記載されている。しかし、このような方法においても、前述した方法と同様に、アルミニウムやその合金と磁性金属材料との変形抵抗が大きく異なることに起因して、プレス成形加工時に接合界面で剥離が生じる等の問題があった。さらに、電磁調理器用容器として加熱・冷却工程が繰り返され加えられると、アルミニウムやその合金と磁性金属材料との熱膨張係数の差によって容器が変形したり、クラッド材の接合界面で剥離が生じる等の問題を有していた。

【0005】一方、金属材料を接合する際に界面強度の向上を図る方法として、例えばホーニングや化学エッチング等により表面積を拡大し、これにより接合面積を増大させる方法が知られている。しかし、ホーニングや化学エッチング等では、接合面積の拡大に限界があり、また界面の剥離せん断に対する抵抗が小さいため、上述したような電磁調理器用容器の構成材料等に適用したとしても十分な効果を得ることはできない。

【0006】

【発明が解決しようとする課題】上述したように、従来の電磁調理器用容器においては、電磁波による加熱効率

を高めるために、磁性金属材料と熱伝導性に優れるアルミニウムやその合金とのクラッド材を用いることが検討されてきたが、それら材料間の変形抵抗が大きく異なるために、加工時に形状変形や接合界面での剥離等が生じやすく、これらにより電磁調理器用容器の熱効率を逆に低下させてしまうという問題があった。

【0007】本発明は、このような課題に対処するためになされたもので、変形抵抗等が異なる異種の金属材料間を十分密着させ、かつ接合強度の向上を図った複合金属材料およびその製造方法を提供することを目的としており、さらには熱効率や信頼性の向上を図った電磁調理器用容器を提供することを目的としている。

【0008】

【課題を解決するための手段と作用】本発明における第1の複合金属材料は、異なる2種の金属材料を積層した複合金属材料であって、前記2種の金属材料間に、一方の前記金属材料に積層固着された多孔性中間層を具備し、他方の前記金属材料の一部が前記中間層内に含有されていることを特徴としている。

【0009】上記第1の複合金属材料の製造方法のうち、第1の製造方法は異なる2種の金属材料を積層した複合金属材料を製造するにあたり、一方の前記金属材料上に、該金属材料と少なくとも親和性を有する材料を接合して多孔性中間層を形成する工程と、他方の前記金属材料を前記多孔性中間層内に含浸しつつ、前記他方の金属材料を前記一方の金属材料に積層する工程とを有することを特徴としている。また、第2の製造方法は、異なる2種の金属材料を積層した複合金属材料を製造するにあたり、一方の前記金属材料上に、該金属材料と少なくとも親和性を有する材料を溶射して多孔性中間層を形成する工程と、他方の前記金属材料を前記多孔性中間層内に含浸しつつ、前記他方の金属材料を前記一方の金属材料に積層する工程とを有することを特徴としている。

【0010】さらに、第3の製造方法は、異なる2種の金属材料を積層した複合金属材料を製造するにあたり、一方の前記金属材料上に、該金属材料と少なくとも親和性を有する材料を電気化学的成膜して多孔性中間層を形成する工程と、他方の前記金属材料を前記多孔性中間層内に含浸しつつ、前記他方の金属材料を前記一方の金属材料に積層する工程とを有することを特徴としている。

【0011】本発明における第2の複合金属材料は、磁性金属材料と高熱伝導性金属材料とを積層した複合金属材料であって、前記磁性金属材料と高熱伝導性金属材料間に中間層として組成傾斜層が設けられていることを特徴としている。

【0012】上記第2の複合金属材料の製造方法は、磁性金属材料と高熱伝導性金属材料とを積層した複合金属材料を製造するにあたり、前記磁性金属材料またはその予備成形体上に、少なくとも前記磁性金属材料を含む多孔層を形成する工程と、前記高熱伝導性金属材料を前記

多孔層内に含浸し、前記磁性金属材料と高熱伝導性金属材料との組成傾斜層を形成しつつ、前記高熱伝導性金属材料を前記磁性金属材料に積層する工程とを有することを特徴としている。

【0013】さらに、本発明の電磁調理器用容器は、少なくとも底部が本発明の第1の複合金属材料または第2の複合金属材料からなることを特徴としている。

【0014】まず、本発明における第1の複合金属材料について述べる。第1の複合金属材料に用いる2種の金属材料としては、例えば磁性金属材料と高熱伝導性材料とが例示されるが、これらに限定されるものではなく、2種の金属材料間での拡散速度が遅く、かつ界面反応しにくい異種材料等に適用可能である。上記磁性金属材料としては、電気抵抗率が $5.0\mu\Omega\cdot\text{cm}$ (20℃) 以上のものが好ましく、例えば鉄およびその合金、各種鋼材、ニッケルおよびその合金等が例示される。また、高熱伝導性材料としては、熱伝導率が $120\text{W/m}\cdot\text{K}$ (273~473K) 以上のものが好ましく、例えばAlやAl合金等が例示される。

【0015】第1の複合金属材料は、一方の金属材料の表面に積層固着された多孔性中間層を形成し、かつ他方の金属材料の一部を多孔性中間層内に含有させ、2種類の金属材料間の接合面積を拡大すると共に、くさび効果を得ることによって、密着性および結合強度、さらには熱伝達効率の向上を図ったものである。

【0016】例えば、図1(a)に示すくさび効果を有する多孔性中間層1を用いた第1の金属材料2と第2の金属材料3との接合面積と、図2(a)に示す従来の一般的な接合面積拡大のためのホーニング面4aを有する第1の金属材料4と第2の金属材料5との接合面積とを比較すると、図1(b)および図2(b)におけるxを1とした場合、図2に示したホーニング面4aでは接合面積が約1.4倍しか増大しないのに対し、図1に示したくさび効果を有する多孔性中間層1では約5.2倍に増大し、さらに多孔性中間層1の厚さに比例して増大する。このように、多孔性中間層1とその内部に含有された第2の金属材料3とが引張方向(図中、矢印Aで示す)に対して複雑に係合して、すなわちくさび効果を発揮して、高接合強度が得られると共に、接合面積が大幅に拡大して、密着性の向上や応力緩和ならびにクラックの伝播防止、さらには熱伝達効率の向上を図ることができる。

【0017】本発明の第1の複合金属材料における多孔性中間層は、例えば少なくとも一方の金属材料と親和性、すなわち良好な結合性や反応性を有し、さらには熱膨張率が近似する等の特性を有する材料(以下、中間層構成材料と記す)の積層固着層である。中間層構成材料の具体例としては、例えば金属材料がステンレス鋼であれば同材や鉄系材料等が例示される。

【0018】上記中間層構成材料の具体的な形状は特に限定されるものではなく、例えば粉末、粒状体、繊維、フ

ィヤ、それらを用いたネットやスポンジ金属のような多孔質プリフォーム等の成形体等が挙げられる。また、これら中間層構成材料の大きさも特に限定されるものではないが、例えば粉末、粒状体、繊維等の場合には、その直径が $1\sim 5000\mu\text{m}$ 程度であることが好ましい。これらの範囲を超えると、いずれも十分なくさび効果が得にくくなる。より好ましい直径は $5\sim 500\mu\text{m}$ の範囲であり、さらに好ましくは $10\sim 200\mu\text{m}$ の範囲である。また、中間層構成材料としてワイヤやネット等を用いる場合には、上記直径範囲に限定されるものではなく、組合せ形状や固着状態等に応じて設定されるものである。

【0019】また、中間層構成材料としては、一方の金属材料と良好な親和性を有する材料と、他方の金属材料と良好な親和性を有する材料との混合物等を用いることもできる。2種類の金属材料間の熱膨張係数の差が大きい場合には、この熱膨張差を緩和するような材料を選択することもでき、これにより応力緩和を図ることができる。さらに、熱膨張係数や気孔率等を制御するために、セラミックス材料等を混合した材料を用いることも可能である。

【0020】上述したような中間層構成材料からなる多孔性中間層を一方の金属材料に積層固着する方法としては、接合法、溶射法、電気化学的成膜法等が例示される。上記接合法としては、固相拡散接合や融着(部分融着を含む)等の焼成接合やろう付け、溶接、通電溶接等の各種の接合方法を適用することができる。例えば、焼成接合は、多孔性中間層を接合しようとする金属材料の表面に、上記中間層構成材料の多孔質塗着層や多孔質加圧成形層等を形成したり、あるいは中間層構成材料による多孔質成形体を積層した後、これらを焼成することにより実施される。また、金属溶射法としては、一般に火炎溶射法やプラズマ溶射法等が知られており、いずれの場合も高温で熔融した金属の粒子を吹き付けることにより、偏平になった金属粒子が重なった層が得られるため、特別な処理を施さない限り、多孔質の金属層が得られる。ただし、溶射しただけの状態での被溶射物(金属材料)と溶射層(多孔性中間層)との結合強度は、一般的には界面に酸化層が生成されるために、拡散反応等の金属的な結合は小さく、界面の凹凸による機械的な絡み合いが主となる。複合金属材料の用途や形状によっては、溶射だけによる結合強度で十分な場合もあるが、さらに大きな結合強度が要求される場合には、例えば真空中にて酸化膜が蒸発するような高温に加熱することにより、被溶射物と溶射層との界面を活性化し、結合強度を増大させることができる。

【0021】上述した溶射法による多孔性中間層の気孔率を高める方法としては、低温領域を選ぶ、溶射ガンと被溶射物との距離を大きくする、溶射材料の供給量を増大させるような溶射条件を選定する等が例示される。さらに、溶射材料としては金属だけでなく、金属とセラミ

ックス等とを混合材料を用いることもできる。このような複合溶射により、溶射層からなる多孔性中間層の熱膨張係数や気孔率、熱伝導率、他方の金属材料を積層する際の反応抑制等を制御することができる。

【0022】さらに、電気化学的成膜法としては、電着法、多孔質メッキ法、放電被覆法等が例示され、これらによっても上述した溶射法等と同様に、多孔性中間層を得ることができる。また、電気化学的成膜を行った後に熱処理を施して、膜（多孔性中間層）と金属材料との結合強度を高めることも可能である。

【0023】また、本発明における多孔性中間層は、多孔質状態とすることが重要であり、具体的には中間層構成材料の体積率を5～65%（気孔率=35～95%）程度とすることが好ましい。体積率が5%未満であると、積層固着する金属材料との十分な強度（結合強度）が得られにくく、また65%を超えると他方の金属材料の含浸量が減少して、接合面積の拡大効果やくさび効果等を十分に得ることができないおそれがある。より好ましい体積率は20～60%であり、さらに好ましくは25～55%である。さらに、上記中間層構成材料の体積率（気孔率）を傾斜、すなわち多孔性中間層が形成される一方の金属材料側から他方の金属材料側に向けて体積率を減少させて、他方の金属材料を体積傾斜に応じて含有させてもよい。このような構成とすることによって、応力緩和を図ることができる。

【0024】上述したような中間層構成材料の体積率を傾斜させた多孔性中間層は、例えば以下のように作製される。すなわち、まず中間層構成材料と有機材料粒子とを混合し、その混合比率を例えば5～30%の範囲で変化させた複数の混合粉末を用意する。有機材料粒子の混合比が最も小さい混合粉末から一方の金属材料上に順次積層した後、真空中で加熱することによって、有機材料粒子を消失させつつ体積率（気孔率）を傾斜させた多孔性中間層を形成する。使用する有機材料としては、加熱により消失しやすい非晶性、熱可塑性の有機材料が適しており、具体的にはスチレン樹脂、塩化ビニル樹脂、アクリル樹脂等が例示される。上記したような体積率を傾斜させた多孔性中間層に他方の金属材料を含浸させると、他方の金属材料と中間層構成材料との組成傾斜中間複合層が形成され、熱膨張係数の段階的な変化をもたらすことができ、熱応力の緩和を図ることが可能となる。

【0025】上述したような多孔性中間層の厚さは、例えば粉末の単層焼付け層等であっても、一方の金属材料に強固に結合していればその効果（接合面積拡大効果やくさび効果等）を得ることができ、特に限定されるものではないが、安定した効果を得る上で1～1000 μm 程度とすることが好ましい。より好ましい中間層の厚さは5～500 μm の範囲であり、さらに好ましくは50～150 μm の範囲である。ただし、中間層の厚さは中間層構成材料の種類や形状に応じて設定することが好ましい。

【0026】本発明の第1の複合金属材料においては、上述した多孔性中間層内に他方の金属材料の一部を含有させつつ積層する。多孔性中間層内に他方の金属材料を含有させる方法としては、当該金属材料の溶湯を含浸させる方法や、当該金属材料の粉末を充填した後に加熱して含浸させる方法が例示される。これらの含浸法によれば、他方の金属材料部分を同時に形成することができる。

【0027】上記溶湯含浸法としては、加圧含浸（溶湯鍛造）、ダイキャスト、低圧鋳造、遠心鋳造等を適用することができる。また、粉末を用いる方法としては、液相焼結、粉末鍛造、ホットプレス等が挙げられる。特に、溶湯加圧含浸法によれば、多孔性中間層の内部まで他方の金属材料を十分に浸入させることができ、良好な密着性を容易に得ることができ、かつ焼結温度が異なる2種類の金属材料を良好に複合化することができる。

【0028】次に、本発明における第2の複合金属材料について述べる。第2の複合金属材料は、磁性金属材料と高熱伝導性金属材料間に中間層として組成傾斜層を設け、それら材料間の応力緩和を図ることによって、接合強度および密着性の向上を図ったものである。なお、磁性金属材料および高熱伝導性金属材料としては、前述した第1の複合金属材料と同様なものが例示される。上記組成傾斜層は、次の2つに大別することができる。

【0029】(1) 磁性金属材料と高熱伝導性金属材料との混合層により組成傾斜層を構成し、単層混合層または体積比率を傾斜させた混合層とする。

【0030】(2) 磁性金属材料、高熱伝導性金属材料およびセラミックス補助材の混合層により組成傾斜層を構成し、混合層中の少なくとも磁性金属材料とセラミックス補助材との体積比率を傾斜させて、熱膨張係数を段階的に変化させる。この際、高熱伝導性金属材料の体積率は必ずしも傾斜させなくてもよい。

【0031】上記(1)による組成傾斜層としては、少なくとも1層の磁性金属材料と高熱伝導性金属材料との混合層を有していればその効果を得ることができ、さらに磁性金属材料から高熱伝導性金属材料に向けて連続的にもしくは段階的に組成を変化させた層とすることが好ましい。組成傾斜層の厚さは特に限定されるものではないが、1～1000 μm 程度とすることが好ましい。また、前述した第1の複合金属材料で説明したように、磁性金属材料の体積比率を変化させた多孔層を中間層として形成し、この中間層に高熱伝導性金属材料を含浸することによって、組成傾斜層を形成することも可能である。磁性金属材料の体積比率を変化させた多孔層の製造方法は、前述した通りである。

【0032】また、上記(2)による組成傾斜層は、例えばセラミックス粉末およびセラミックス繊維から選ばれる少なくとも1層を組成傾斜補助材（セラミックス補助材）として添加したものであり、このセラミックス補助

材と磁性金属材料との体積比率を少なくとも傾斜させる。セラミックス粉末やセラミックス繊維等のセラミックス補助材は、磁性金属材料と高熱伝導性金属材料間の熱膨張差の緩和に寄与すると共に、強度向上（分散強化）にも寄与するものである。よって、セラミックス補助材を（1）の組成傾斜層の強度向上材として添加することも可能である。

【0033】上述したようなセラミックス粉末や繊維の材質としては、例えばAl、Si、Ti、Zr、Ta、Cr等の酸化物、窒化物、炭化物、あるいはこれらの複合化物等が例示される。用いるセラミックス粉末や繊維はその直径が0.05～500 μm 程度のものが好ましい。また、セラミックス粉末や繊維の含有量としては、組成傾斜層の厚さや種類等によっても異なるが、組成傾斜層の全体積に対して5～50体積%の範囲とすることが好ましい。

【0034】上述したような第2の複合金属材料は、例えば以下のようにして製造することが好ましい。

【0035】すなわち、磁性金属材料の板材またはその予備成形体上に、少なくとも磁性金属材料を含む多孔層を冷間圧縮成形等により形成する。磁性金属材料の予備成形体としては、磁性金属材料粉末の圧粉成形体等が例示される。この圧粉成形体の密度は特に制限はないが、密度が80%未満であると例えば電磁誘導加熱効率が低くなるために、80%以上とすることが好ましい。

【0036】上記多孔層は組成傾斜層となるものであり、予め高熱伝導性金属材料を含有させておいてもよい。この予め含有させる高熱伝導性金属材料は、冷間圧縮多孔層（予備成形体）の強度改善に寄与する。また、組成を段階的に変化させた組成傾斜層を形成する場合には、多孔層の形成段階で少なくとも磁性金属材料の組成を変化させた多層構造を作製する。さらに、セラミックス補助材を含有させて組成傾斜層を形成する場合には、磁性金属材料とセラミックス補助材との混合比を変化させた多層構造の多孔層を形成する。

【0037】上記（1）による組成傾斜層の場合、多孔層の空間率により基本的には組成傾斜層内の高熱伝導性金属材料の組成比が決定される。よって、多孔層の体積率は設定した組成傾斜層の組成に応じて決定する。このような多孔層の体積率は、多孔層の強度と高熱伝導性金属材料溶湯の含浸性を考慮して、10～60%程度とすることが好ましい。また、上記（2）による組成傾斜層は、磁性金属材料とセラミックス補助材との混合比により、基本的には組成傾斜状態（熱膨張係数の変化状態）が決定されるため、多孔層の体積率（気孔率）は必ずしも変化させなくてもよい。多孔層の体積率は上述した通りである。

【0038】そして、高熱伝導性金属材料を上記多孔層内に含浸して、組成傾斜層を形成しつつ高熱伝導性金属材料を磁性金属材料上に積層する。金属材料の含浸法としては、前述した第1の複合金属材料の製造方法で説明

したように、当該金属材料の溶湯を含浸させる方法や、当該金属材料の粉末を充填した後に加熱して含浸させる方法等を適用することができる。このようにして、目的とする複合金属材料が得られる。上記含浸法のうち特に溶湯加圧含浸法によれば、組成傾斜層となる多孔層の内部まで高熱伝導性金属材料を十分に浸入させることができ、良好な組成傾斜層を容易に得ることができると共に、変形抵抗や焼結温度等が異なる2種類の金属材料を良好に複合化することができる。

【0039】本発明の電磁調理器用容器は、少なくとも容器底部を上述したような本発明の第1の複合金属材料または第2の複合金属材料で構成したものであり、基本的には磁性金属材料が外周側に配置される。本発明の複合金属材料は、前述したように密着性に優れると共に接合強度に優れ、かつ異種金属材料間の熱膨張差に起因する応力を緩和しているため、熱衝撃が印加された場合においても界面剥離等を招くおそれが極めて少ない。また、接合面積の拡大によって、熱伝達効率をより一層向上させることができる。従って、電磁調理器用容器の熱効率および信頼性を大幅に向上させることが可能となる。

【0040】

【実施例】以下、本発明の実施例について説明する。

【0041】実施例1

まず、第1の金属材料（磁性材料）として直径10mm、高さ15mmの1重量%ケイ素鋼製円柱（電気抵抗率 $=25\mu\Omega\cdot\text{cm}$ ）を用意し、これを同直径の金型内に設置した後、その上に中間層構成材料として、平均粒径100 μm の純鉄粉末を充填し、層厚1mm、体積率50%の圧粉層となるように成形した。次いで、この圧粉層を $1.33\times 10^{-2}\text{Pa}$ の真空中にて1373Kで2時間焼成して、ケイ素鋼製円柱上端面に接合された多孔質状態の中間層を形成した。

【0042】次に、上記多孔性中間層を有するケイ素鋼製円柱を673Kに予熱した溶湯鍛造の金型内に配置し、この金型内に1053KのAl合金（6061、熱伝導率 $=167\text{W/m}\cdot\text{K}$ ）溶湯を注入し、多孔性中間層内にAl合金溶湯を98MPaの圧力で加圧含浸しつつ、第2の金属材料（高熱伝導性材料）として厚さ15mmのAl合金層を形成した。

【0043】このようにして得た複合金属材料の引張強度を以下のようにして測定した。まず、上記複合材料から長さ30mm、標点間直径5mmで、中間層が標点間の中央に位置する引張り試験片を作製し、この試験片を用いて引張試験を行った。その結果、引張強度は196MPaという良好な値が得られ、また破断位置はAl合金層と中間層の間であった。

【0044】実施例2

第1の金属材料として直径10mm、高さ15mmのステンレス（SUS430）製円柱（電気抵抗率 $=60\mu\Omega\cdot\text{cm}$ ）を用意し、これを同直径の金型内に設置した後、その上に中間層構成材料として、平均粒径100 μm のステンレス（SUS430）

粉末を充填し、層厚0.25mm、体積率 65%の圧粉層となるように成形した。次いで、この圧粉層を 1.33×10^{-2} Paの真空中にて 1373Kで 2時間焼成して、ステンレス製円柱上端面に接合された多孔質状態の中間層を形成した。

【0045】次に、上記多孔性中間層を有するステンレス製円柱を673Kに予熱した溶湯鍛造の金型内に配置し、この金型内に 1053KのAl合金(ADC12、熱伝導率=96W/m K)溶湯を注入し、多孔性中間層内にAl合金溶湯を 98MPaの圧力で加圧含浸しつつ、第2の金属材料として厚さ15mmのAl合金層を形成した。

【0046】このようにして得た複合金属材料から実施例1と同様に引張試験片を作製し、引張試験を実施したところ、引張強さは206MPaという良好な値が得られ、また破断位置はAl合金層と中間層の間であった。

【0047】また、上記複合金属材料の接合界面近傍の組織を走査型電子顕微鏡により観察した。その結果として、接合界面近傍の走査型電子顕微鏡写真を図3に示す。なお、図3(a)は中間層を含む接合界面近傍の拡大写真(倍率:200倍)であり、図3(b)はその中間層内をさらに拡大(倍率:1000倍)した電子顕微鏡写真である。これらの写真から明らかなように、第2の金属材料であるAl合金が多孔性中間層内に侵入して、接合面積が大幅に拡大されていると共に、良好なくさび効果が得られていることが分かる。また、Al合金と多孔性中間層との密着性も良好であることが分かる。

【0048】実施例3

第1の金属材料として直径10mm、高さ15mmの純鉄製円柱(電気抵抗率=9.8 $\mu\Omega \cdot \text{cm}$)を用意し、これを同直径の金型内に設置した後、その上に中間層構成材料として、平均粒径 100 μm の純鉄粉末と平均直径 3 μm 、平均長さ 3mmのアルミナ繊維との混合物を充填し、層厚 1mm、体積率 35%(純鉄粉末の体積率=15%、アルミナ繊維の体積率=20%)の粉末繊維混合層となるように成形した。次いで、この粉末繊維混合形成層を 1.33×10^{-2} Paの真空中にて 1373Kで 2時間焼成して、純鉄製円柱上端面に接合された多孔質状態の中間層を形成した。

【0049】次に、上記多孔性中間層を有する純鉄製円柱を673Kに予熱した溶湯鍛造の金型内に配置し、この金型内に 1053KのAl合金(AC8B、熱伝導率=117W/m K)溶湯を注入し、多孔性中間層内にAl合金溶湯を 98MPaの圧力で加圧含浸しつつ、第2の金属材料として厚さ15mmのAl合金層を形成した。

【0050】このようにして得た複合金属材料から実施例1と同様に引張試験片を作製し、引張試験を実施したところ、引張強さは226MPaという良好な値が得られ、また破断位置はAl合金層と中間層の間であった。

【0051】実施例4

第1の金属材料として直径10mm、高さ15mmの純鉄製円柱を用意し、これを同直径の金型内に設置した後、その上に中間層構成材料として、平均粒径10 μm の純鉄粉末と

直径0.05~1.5 μm 、アスペクト比20~200のSiCウィスカーとの混合物を充填し、層厚 1mm、体積率 25%(純鉄粉末の体積率=10%、SiCウィスカーの体積率=15%)の粉末繊維混合層となるように成形した。次いで、この粉末繊維混合形成層を 1.33×10^{-2} Paの真空中にて 1373Kで 2時間焼成して、純鉄製円柱上端面に接合された多孔質状態の中間層を形成した。

【0052】次に、上記多孔性中間層を有する純鉄製円柱を673Kに予熱した溶湯鍛造の金型内に配置し、この金型内に 1053KのAl合金(4032、熱伝導率=146W/m K)溶湯を注入し、多孔性中間層内にAl合金溶湯を 98MPaの圧力で加圧含浸しつつ、第2の金属材料として厚さ15mmのAl合金層を形成した。

【0053】このようにして得た複合金属材料から実施例1と同様に引張試験片を作製し、引張試験を実施したところ、引張強さは245MPaという良好な値が得られ、また破断位置はAl合金層と中間層の間であった。

【0054】実施例5

第1の金属材料として直径10mm、高さ15mmの純鉄製円柱を用意し、この純鉄製円柱の端面に、中間層構成材料である平均粒径10 μm の純鉄粉末を有機系バインダと共に混合したものを吹き付け、層厚10 μm 、体積率5%の粉末塗着層を形成した。次いで、この粉末塗着層を 1.33×10^{-2} Paの真空中にて 1373Kで 2時間焼成して、純鉄製円柱上端面に接合された多孔質状態の中間層を形成した。

【0055】次に、上記多孔性中間層を有する純鉄製円柱を673Kに予熱した溶湯鍛造の金型内に配置し、この金型内に 1053KのAl合金(1200、熱伝導率=218W/m K)溶湯を注入し、多孔性中間層内にAl合金溶湯を 98MPaの圧力で加圧含浸しつつ、第2の金属材料として厚さ15mmのAl合金層を形成した。

【0056】このようにして得た複合金属材料から実施例1と同様に引張試験片を作製し、引張試験を実施したところ、引張強さは167MPaという良好な値が得られ、また破断位置はAl合金層と中間層の間であった。

【0057】実施例6

第1の金属材料として直径 250mm、厚さ 0.6~1.0mmのステンレス(SUS430)製円板(電気抵抗率=60 $\mu\Omega \cdot \text{cm}$)を用意し、このステンレス製円板の表面に、表1に示す各溶射材をそれぞれ表1に示す溶射条件に従って溶射した後、 1.33×10^{-2} ~ 1.33×10^{-4} Paの真空中にて1253~1473K×2時間の条件下で真空拡散熱処理を施して多孔性中間層をそれぞれ得た。

【0058】次に、上記各種多孔性中間層を有するステンレス製円板を、それぞれ673Kに予熱した溶湯鍛造の金型内に配置し、この金型内に1023~1073KのAl溶湯を注入して、多孔性中間層内にAl溶湯を40~98MPaの圧力で加圧含浸しつつ、第2の金属材料としてAl層を形成した。なお、冷却は加圧状態を維持しつつ行った。

【0059】このようにして得た各複合金属材料から実

施例 1 と同様に引張試験片を作製して引張試験を実施した。その結果を表 1 に併せて示す。また、各複合金属材料を 673K に加熱した後に水中に焼き入れても、その衝撃

で剥離することはなかった。

【表 1】

試料 No	溶射材	溶射法 (熱源)	溶射距離 (mm)	溶射層の 厚さ (μm)	溶射層の 気孔率 (%)	引張強度 (MPa)
1	SUS 430	プラズマ	150	50	15	230
2	Ni	アーク	250	150	16	245
3	鉄	火炎	300	200	26	240
4	SUS 430	プラズマ	150	80	12	175
5	Cu	火炎	350	150	30	250
6	Ni+Al	プラズマ	150	100	32	255

実施例 7

*：体積率は 1:1

第 1 の金属材料として直径 10mm、厚さ 150mm のステンレス (SUS430) 製円柱 (電気抵抗率=60 μΩ・cm) を用意し、このステンレス製円柱の表面に、下記に詳述する Ni メッキとアルミナ粒子の電泳塗装による複合メッキを施して、層厚 40 μm、体積率 75% の電気化学的成膜層による多孔性中間層を得た。

【0060】複合メッキは、以下のように行った。まず、硫酸ニッケル 150g/l、塩化ニッケル 15g/l、ホウ酸 15g/l を含む Ni メッキ液 (pH=6) を準備し、これに平均粒径 10 μm のアルミナ粒子を 200g/l の割合で混合した。このメッキ液の中に、上記ステンレス製円柱を陰極として挿入し、電流密度 3A/dm² でメッキを行った。これにより、Ni メッキ層内にアルミナ粒子が体積率 10% の割合で含まれ、気孔率が 25% の多孔性複合層を得た。この多孔性複合層に 1.33×10⁻³Pa の真空中で 1373K×5 時間の条件で拡散処理を施して多孔性中間層とした。

【0061】次に、上記電気化学的成膜による多孔性中間層を有するステンレス製円柱を 673K に予熱した溶湯鍛造の金型内に配置し、この金型内に 1053K の Al 合金 (6061、熱伝導率=167W/m K) 溶湯を注入し、多孔性中間層内に Al 合金溶湯を 98MPa の圧力で加圧含浸しつつ、第 2 の金属材料 (高熱伝導性材料) として厚さ 15mm の Al 合金層を形成した。

【0062】このようにして得た複合金属材料から実施例 1 と同様に引張試験片を作製し、引張試験を実施したところ、引張強さは 215MPa という良好な値が得られ、また破断位置は Al 合金層と中間層の間であった。

【0063】実施例 8

まず、実施例 2 と同様にして、多孔性中間層を有するステンレス製円柱を作製した。次に、この多孔性中間層を有するステンレス製円柱を金型内に配置し、この金型内に適正な量の Al 合金 (6061、熱伝導率=167W/m K) 粉末を導入した。次いで、大気中で粉末温度を上記 Al 合金の液相温度である 855K より 50K 高い 903K に保持した後、40~58MPa の圧力を上金型により加えて、第 2 の金属材料と

して厚さ 20mm で密度 100% の Al 合金層を形成した。上記液層温度以上の温度下での加圧によって、初期粒子間の酸化膜は破壊するので十分な伸びを有した成形体を得られると共に、多孔性中間層内に Al 合金を良好に含浸することができる。

【0064】このようにして得た複合金属材料から実施例 1 と同様に引張試験片を作製し、引張試験を実施したところ、引張強さは 180MPa という良好な値が得られ、また破断位置は Al 合金層と中間層の間であった。なお、上記実施例では大気中にて粉末鍛造を行ったが、真空中で粉末鍛造を行うことで、より良好な結果を得ることができる。

【0065】実施例 9

第 1 の金属材料として幅 10mm、長さ 100mm、厚さ 5mm のニッケル板 (電気抵抗率=10.3 μΩ・cm、熱膨張係数=13.4×10⁻⁶/K) を用意し、このニッケル板の表面に平均粒径 40 μm のステンレス (SUS304) 粉末 (熱膨張係数=17.3×10⁻⁶/K) と、直径 1.0 μm、長さ 50 μm の SiC ウィスカ (熱膨張係数=3.2×10⁻⁶/K) とを混合した 2 種類の混合物を順に塗布して、2 層構造の多孔質層を形成した。この 2 層構造の多孔質層は、まずニッケル板の表面にステンレス (SUS304) 粉末と SiC ウィスカの重量比を 10:1 とした厚さ 30 μm の多孔質層を形成し、さらにその上にステンレス (SUS304) 粉末と SiC ウィスカの重量比を 2.5:1 とした厚さ 30 μm の多孔質層を形成した。それぞれの体積比はおおよそ 4:1 と 1:1 である。次いで、この 2 層構造の多孔質層を、実施例 1 と同様に 1.33×10⁻²Pa の真空中にて 1373K で 2 時間焼成した。

【0066】次に、上記 2 層構造の多孔質層を形成したニッケル板を 673K に予熱した溶湯鍛造の金型内に配置し、この金型内に 1053K の Al 合金 (AC8B、熱伝導率=117 W/m K、熱膨張係数=22×10⁻⁶/K) 溶湯を注入し、多孔質層内に Al 合金溶湯を 98MPa の圧力で加圧含浸して組成傾斜層を形成しつつ、第 2 の金属材料として厚さ 5mm の Al 合金層を形成した。

【0067】このようにして得た複合金属材料を 723K に

加熱した後、直接水中に投入して急冷したところ、熱膨張係数の差に起因する変形は生じたものの、接合界面に亀裂等は何等生じなかった。なお、参考例として、鉄粉末のみで厚さ $60\mu\text{m}$ の多孔質層を形成して、上記実施例と同様に、真空焼結およびAl合金の溶湯鍛造含浸を行って試験片を作製し、同様な水中急冷を行ったところ、Al合金層と多孔質層との界面に亀裂が生じた。

【0068】実施例10

第1の金属材料として幅10mm、長さ100mm、厚さ5mmのステンレス(SUS430)板(電気抵抗率 $=10.3\mu\Omega\cdot\text{cm}$ 、熱膨張係数 $=13.4\times 10^{-6}/\text{K}$)を用意して、このステンレス板の表面にまず平均粒径 $10\mu\text{m}$ の鉄粉末を厚さ $50\mu\text{m}$ となるように塗布し、次いで上記鉄粉末と直径 $40\mu\text{m}$ のポリスチロール粒子とを混合(体積混合比 $=3:1$)した粉末を厚さ $50\mu\text{m}$ となるように塗布した。次いで、実施例1と同様に $1.33\times 10^{-2}\text{Pa}$ の真空中にて1373Kで2時間焼成して、鉄粉末同士および鉄粉末とステンレス板との拡散接合を行うと同時に、ポリスチロール粒子を分解、揮散させた。ポリスチロール粒子が存在していた位置には約 $35\mu\text{m}$ の孔が残った。鉄粉末の体積率は約70%と約55%となり、体積比率が傾斜された多孔質層が形成されていることを確認した。

【0069】次に、上記体積比率を傾斜させた多孔質層を形成したステンレス板を673Kに予熱した溶湯鍛造の金型内に配置し、この金型内に1053KのAl合金(AC8B、熱伝導率 $=117\text{W}/\text{m}\cdot\text{K}$ 、熱膨張係数 $=22\times 10^{-6}/\text{K}$)溶湯を注入し、多孔質層内にAl合金溶湯を98MPaの圧力で加圧含浸して組成傾斜層を形成しつつ、第2の金属材料として厚さ5mmのAl合金層を形成した。

【0070】このようにして得た複合金属材料を723Kに加熱した後、直接水中に投入して急冷したところ、熱膨張係数の差に起因する変形は生じたものの、接合界面に亀裂等は何等生じなかった。なお、参考例として、鉄粉末のみで厚さ $100\mu\text{m}$ の多孔質層を形成して、上記実施例と同様に、真空焼結およびAl合金の溶湯鍛造含浸を行って試験片を作製し、同様な水中急冷を行ったところ、Al合金層と多孔質層との界面に亀裂が生じた。

【0071】比較例1

直径10mm、高さ15mmのS45C製円柱の端面を、粗さ $R_{\text{max}}=50\mu\text{m}$ となるようにホーニングした後、同直径の溶湯鍛造の金型内に設置した。次いで、この金型内に1053KのAl合金(6061)溶湯を注入して、厚さ15mmのAl合金層を形成した。この複合金属材料から実施例1と同様に引張試験片を作製し、引張試験を実施したところ、引張り強さは30MPa未満と低い値しか得られなかった。

【0072】比較例2

直径10mm、高さ15mmのステンレス(SUS430)製円柱の端面を、粗さ $R_{\text{max}}=50\mu\text{m}$ となるようにフォトリソグラフィを行った後、同直径の溶湯鍛造の金型内に設置した。次いで、この金型内に1053KのAl合金(6061)溶湯を注入し

て、厚さ15mmのAl合金層を形成した。この複合金属材料から実施例1と同様に引張試験片を作製し、引張試験を実施したところ、引張り強さは35MPa未満と低い値しか得られなかった。

【0073】次に、本発明の電磁調理器用容器の実施例について述べる。

【0074】実施例11

直径250mm、厚さ0.6mmのステンレス(SUS430)製円板を用意し、このステンレス製円板の端面に平均粒径 $100\mu\text{m}$ の純鉄粉末を有機系バインダと共に混合したものを吹き付けて、層厚0.5mm、純鉄粉末の体積率が15%の粉末塗着層を形成した。次いで、この粉末塗着層を $1.33\times 10^{-2}\text{Pa}$ の真空中にて1426Kで2時間焼成して、ステンレス製円板に接合された多孔質状態の中間層を形成した。

【0075】次に、表面部に多孔性中間層を有するステンレス製円板を、673Kに予熱した電磁調理器用容器形状の金型の底部に配置し、この容器用金型内に1073KのAl合金(ADC12)溶湯を注入し、多孔性中間層内にAl合金溶湯を98MPaの圧力で加圧含浸しつつ、容器壁がAl合金からなる電磁調理器用容器(鍋)を作製した。すなわち、図4に示すように、Al合金層11とステンレス層12とをAl合金を含浸させた多孔性中間層13を介して積層接合した複合金属材料14で底部15aを構成すると共に、それ以外の容器壁15bをAl合金で構成した電磁調理器用容器(鍋)15を得た。

【0076】このようにして得た底部が複合金属材料からなる容器を用いて、電磁調理器上で298Kの水1500ccの加熱試験を行ったところ、250秒で沸騰した。一方、本発明との比較として、底部をSUS430とAl合金(ADC12)とのクラッド材で構成した容器を用いて同様に加熱試験を行ったところ、沸騰までに320秒かかった。このように、本発明の電磁調理器用容器においては、磁性金属材料(SUS430)と高熱伝導性材料(Al合金(ADC12))との良好な密着性が得られると共に、その接合界面の信頼性や熱伝達効率に優れることから、熱効率の向上を図ることができる。

【0077】また、上記実施例の電磁調理器用容器に常温から823Kまでの加熱・冷却による熱衝撃試験を施したところ、1000回の加熱・冷却の後においても接合界面等に剥離は認められず、熱衝撃性に優れていることを確認した。一方、上記比較例による容器では、250回の加熱・冷却後に剥離が発生した。

【0078】実施例12

上記実施例11における電磁調理器用容器(鍋)15の底部15aを、前述した実施例6、7と同一工程で作製した複合金属材料とする以外は、実施例11と同様にし、それぞれ電磁調理器用容器(鍋)15を作製した。これら電磁調理器用容器(鍋)15の特性を実施例11と同様に評価したところ、実施例11と同等の良好な結果が得られた。

【0079】実施例13

上記実施例11における電磁調理器用容器（鍋）15の底部15aにおけるAl合金層11および容器壁15bを、前述した実施例8と同一工程で作製する以外は、実施例9と同様にして電磁調理器用容器（鍋）15を作製した。この電磁調理器用容器（鍋）15の特性を実施例11と同様に評価したところ、実施例11と同等の良好な結果が得られた。

【0080】実施例14

平均粒径 $150\mu\text{m}$ のステンレス(SUS430)粉末を約686MPaの圧力で加圧成形した直径200mm、厚さ1mm、密度95%の成形体を、 $1.33 \times 10^{-3}\text{Pa}$ の真空中にて1473K、1時間で焼結して磁性金属粉末層を作製した。この磁性金属粉末層上に、ステンレス(SUS430)粉末とAl合金(AC8C)粉末との混合粉末層を、体積率が50%(ステンレス粉末の体積率=25%、Al合金の体積率=25%)となるように成形した。このようにして、磁性金属層と組成傾斜層との予備成形体を作製した。

【0081】次に、上記磁性金属層と組成傾斜層との予備成形体を、723Kに予熱した電磁調理器用容器形状の金型（直径=220mm）の底部に配置し、この容器用金型内に1073KのAl合金(AC8C)溶湯を注入し、組成傾斜層となる混合粉末成形層にAl合金溶湯を98MPaの圧力で加圧含浸しつつ、容器壁がAl合金からなる電磁調理器用容器

（鍋）を作製した。すなわち、図5に示すように、Al合金層21とステンレス層22とを、Al合金とステンレス(SUS430)とを体積比で3:1で含有する組成傾斜層23を介して積層接合した複合金属材料24で底部を構成すると共に、それ以外の容器壁をAl合金で構成した電磁調理器用容器（鍋）を得た。

【0082】このようにして得た底部が複合金属材料からなる容器を用いて、電磁調理器上で298Kの水1500ccの加熱試験を行ったところ、250秒で沸騰した。また、常温から523Kまでの加熱・冷却による熱衝撃試験を行ったところ、1000回の加熱・冷却の後においても接合界面等に剥離は認められなかった。

【0083】実施例15

平均粒径 $150\mu\text{m}$ のステンレス(SUS430)粉末を約686MPaの圧力で加圧して、直径200mm、厚さ1mm、密度95%の磁性金属粉末層を作製した。次いで、ステンレス(SUS430)粉末とアルミナ繊維との混合物を用いて、上記磁性金属粉末層上に、体積率が60%(ステンレス粉末の体積率=50%、アルミナ繊維の体積率=10%)の第1の層と、体積率が60%(ステンレス粉末の体積率=25%、アルミナ繊維の体積率=35%)の第2の層とを順に成形した。このようにして、磁性金属層と2層構造の組成傾斜層との予備成形体を作製した。

【0084】次に、上記磁性金属層と2層構造の組成傾斜層との予備成形体を、723Kに予熱した電磁調理器用容器形状の金型（直径=220mm）の底部に配置し、この容器

用金型内に800℃のAl合金(AC8C)溶湯を注入し、組成傾斜層となる2層構造の混合物成形層にAl合金溶湯を98MPaの圧力で加圧含浸しつつ、容器壁がAl合金からなる電磁調理器用容器（鍋）を作製した。すなわち、図6に示すように、Al合金層21とステンレス層22とを、2層構造の組成傾斜層25（第1の層25a（ステンレス=50%、Al合金=40%、アルミナ繊維=10%）と第2の層25b（ステンレス=25%、Al合金=40%、アルミナ繊維率=35%））を介して積層接合した複合金属材料26で底部を構成すると共に、それ以外の容器壁をAl合金で構成した電磁調理器用容器（鍋）を得た。

【0085】このようにして得た底部が複合金属材料からなる容器を用いて、電磁調理器上で298Kの水1500ccの加熱試験を行ったところ、250秒で沸騰した。また、常温から523Kまでの加熱・冷却による熱衝撃試験を行ったところ、1000回の加熱・冷却の後においても接合界面等に剥離は認められなかった。

【0086】

【発明の効果】以上説明したように本発明によれば、変形抵抗等が異なる異種の金属材料間を十分密着させると共に、優れた接合強度が得られ、かつ接合界面の信頼性に優れた複合金属材料を提供することが可能となる。従って、このような複合金属材料を用いることにより、熱効率や信頼性を大幅に向上させた電磁調理器用容器を提供することが可能となる。

【図面の簡単な説明】

【図1】 本発明の複合金属材料の中間層を含む接合界面の状態および接合面積の拡大効果を示す図である。

【図2】 本発明との比較として掲げた複合金属材料の中間層を含む接合界面の状態および接合面積の拡大効果を示す図である。

【図3】 本発明の一実施例による複合金属材料の中間層を含む接合界面近傍の微細組織を拡大して示す走査型電子顕微鏡写真である。

【図4】 本発明の一実施例による電磁調理器用容器の構造を示す断面図である。

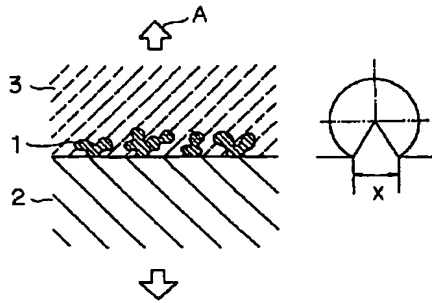
【図5】 本発明の他の実施例による電磁調理器用容器の要部構造を示す断面図である。

【図6】 本発明のさらに他の実施例による電磁調理器用容器の要部構造を示す断面図である。

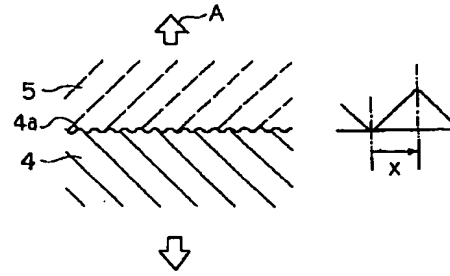
【符号の説明】

- 11、21……Al合金層
- 12、22……ステンレス層
- 13……多孔性中間層
- 14、24、26……複合金属材料
- 15……電磁調理器用容器
- 15a……容器底部
- 23……組成傾斜層
- 25……2層構造の組成傾斜層

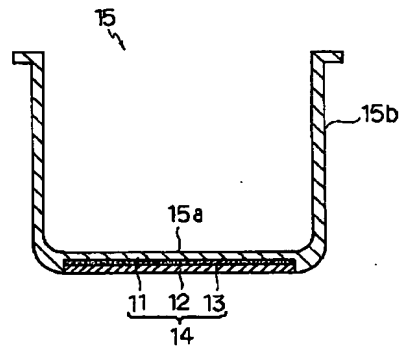
【図1】



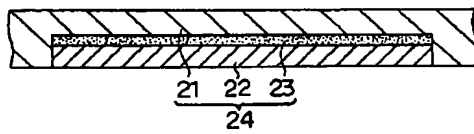
【図2】



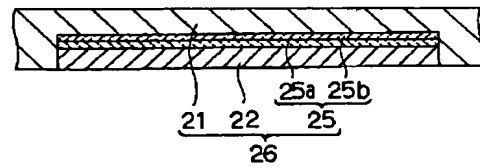
【図4】



【図5】



【図6】



【図3】

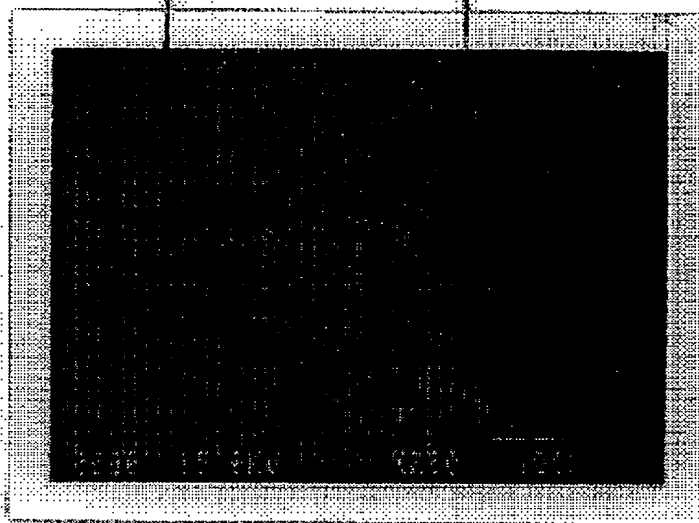
図面代用写真

SUS430

中間層

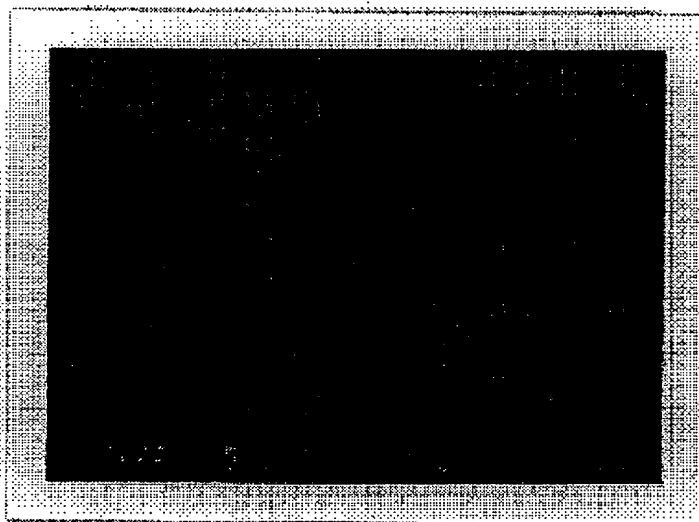
ADC12

(a)



写真

(b)



写真

フロントページの続き

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CLAIMS

[Claim(s)]

[Claim 1] It differs. It is the compound metallic material which carried out the laminating, and two sorts of metallic materials are described above. Compound metallic material characterized by providing the porous interlayer by whom laminating fixing was done in said one metallic material, and said some of metallic materials of another side containing in said interlayer among two sorts of metallic materials.

[Claim 2] a compound metallic material according to claim 1 -- setting -- said -- it differs Compound metallic material characterized by for one side being a magnetic material among two sorts of metallic materials, and another side being a highly thermally-conductive material.

[Claim 3] It is the compound metallic material characterized by being the junctional zone of the ingredient with which said porous interlayer has one [said] metallic material and compatibility in a compound metallic material according to claim 1 or 2.

[Claim 4] It is the compound metallic material characterized by being the thermal-spraying layer of the ingredient with which said porous interlayer has one [said] metallic material and compatibility in a compound metallic material according to claim 1 or 2.

[Claim 5] It is the compound metallic material characterized by being the electrochemical membrane formation layer of the ingredient with which said porous interlayer has one [said] metallic material and compatibility in a compound metallic material according to claim 1 or 2.

[Claim 6] It is the compound metallic material characterized by, as for said porous interlayer, for the rate of the volume inclining, and containing the metallic material of said another side in a compound metallic material according to claim 1 or 2 according to said porous interlayer's volume inclination.

[Claim 7] It differs. The manufacture approach of the compound metallic material characterized by having the process which in manufacturing the compound metallic material which carried out the laminating of two sorts of metallic materials joins this metallic material and the ingredient which has compatibility at least, and forms a porous interlayer on said one metallic material, and the process which carries out the laminating of the metallic material of said another side to one [said] metallic material, sinking in said metallic material of another side into said porous interlayer.

[Claim 8] It differs. The manufacture approach of the compound metallic material characterized by having the process which in manufacturing the compound metallic material which carried out the laminating of two sorts of metallic materials carries out thermal spraying of this metallic material and the ingredient which has compatibility at least, and forms a porous interlayer on said one metallic material, and the process which carries out the laminating of the metallic material of said another side to one [said] metallic material, sinking in said metallic material of another side into said porous interlayer.

[Claim 9] It differs. The manufacture approach of the compound metallic material characterized by having the process which in manufacturing the compound metallic material which carried out the laminating of two sorts of metallic materials carries out electrochemical membrane formation of this metallic material and the ingredient which has compatibility at least, and forms a porous interlayer on said one metallic material, and the process which carries out the laminating of the metallic material of said another side to one [said] metallic material, sinking in said metallic material of another side into said porous interlayer.

[Claim 10] The manufacture approach of the compound metallic material characterized by infiltrating the molten metal of the metallic material of said another side into said porous interlayer in the manufacture approach of claim 7 and a compound metallic material according to claim 8 or 9.

[Claim 11] The manufacture approach of the compound metallic material characterized by making it heat and sink in into said porous interlayer in the manufacture approach of claim 7 and a compound metallic material according to claim 8 or 9 after being filled up with the powder of the metallic material of said another side.

[Claim 12] The compound metallic material which is a compound metallic material which carried out the laminating of a magnetic metallic material and the high temperature conductivity metallic material, and is characterized by preparing the presentation inclined layer as an interlayer between said magnetic metallic material and a high temperature conductivity metallic material.

[Claim 13] It is the compound metallic material characterized by for said presentation inclined layer consisting of a mixolimnion of said magnetic metallic material and a high temperature conductivity metallic material in a compound metallic material according to claim 12, and the rate of a volume ratio in said mixolimnion inclining.

[Claim 14] It is the compound metallic material which said presentation inclined layer consists of a mixolimnion of said magnetic metallic material, a high temperature conductivity metallic material, and a ceramic nominal member in a compound metallic material according to claim 12, and is characterized by the thing in said mixolimnion which the rate of a volume ratio of said magnetic metallic material and ceramic nominal member inclines at least.

[Claim 15] The process which forms the porous layer which contains said magnetic metallic material at least on said magnetic metallic material or its preforming object in manufacturing the compound metallic material which carried out the laminating of a magnetic metallic material and the high temperature conductivity metallic material, The manufacture approach of the compound metallic material characterized by having the process which carries out the laminating of said high temperature conductivity metallic material to said magnetic metallic material, sinking in said high temperature conductivity metallic material into said porous layer, and forming the presentation inclined layer of said magnetic metallic material and a high temperature conductivity metallic material.

[Claim 16] The container for induction heating cookers with which a pars basilaris ossis occipitalis is characterized by consisting of a compound metallic material according to claim 2 at least.

[Claim 17] The container for induction heating cookers with which a pars basilaris ossis occipitalis is characterized by consisting of a compound metallic material according to claim 12 at least.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] It is related with this invention, the compound metallic material which carried out the laminating of two sorts of metallic materials and its manufacture approach, and the container for induction heating cookers using it.

[0002]

[Description of the Prior Art] In recent years, the induction heating cooker attracts attention from the point of safety by making arrival of an aging society, upper-layers-ization of a residence, etc. into a background. Using the composite material which carried out laminating junction of the metallic material which was excellent in thermal conductivity like aluminum or its alloy as a component of the container for induction heating cookers, and the magnetic metallic materials excellent in the electromagnetic heating property, such as iron and stainless steel, by the clad method etc. is examined. That is, it is lightweight and is going to tell the heat in which induction was carried out to the magnetic metallic material by the electromagnetic wave effective in a cooked ingredient with the aluminum which is excellent in thermal conductivity, or its alloy.

[0003] If the concrete production approach of the conventional container for induction heating cookers is explained, using what carried out the clad of aluminum, its alloy, and the magnetic metallic material with roll rolling, performed press-forming processing of deep drawing etc. to this clad plate, and was made into the container configuration is indicated by JP,3-4440,A, for example. However, since the deformation resistance of aluminum, its alloy, and a magnetic metallic material differed greatly, such a clad plate had the big problem in workability -- move in a zigzag direction at the time of rolling junction, or a wrinkling arises. Moreover, when deep drawing etc. carried out press-forming processing of the above-mentioned clad plate and it considered as a container configuration, it originated in the deformation resistance mentioned above differing greatly, and exfoliation arose in the junction interface, there was a fault of ****, and there was a problem of reducing greatly the thermal efficiency of the container for induction heating cookers by this.

[0004] Moreover, using what joined aluminum, its alloy, and a magnetic metallic material by direction inflatable flexible bag techniques, such as between heat, carried out press-forming processing of this composite, and was made into the container configuration is indicated by JP,5-116244,A, for example. However, also in such an approach, it originated in the deformation resistance of aluminum, its alloy, and a magnetic metallic material differing greatly like the approach mentioned above, and there were problems, like exfoliation arises in a junction interface at the time of press-forming processing. Furthermore, when heating / cooling process was repeatedly added as a container for induction heating cookers, the container deformed according to the difference of the coefficient of thermal expansion of aluminum, its alloy, and a magnetic metallic material, and it had problems, like exfoliation arises in the junction interface of a clad plate.

[0005] On the other hand, in case a metallic material is joined, as an approach of aiming at improvement in interface reinforcement, surface area is expanded by honing, chemical etching, etc., and the method of increasing a plane-of-composition product by this is learned. However, neither in honing nor chemical etching, since the resistance to ** in which a limitation is in expansion of a plane-of-composition product, and an interface does not exfoliate is small, even if it applies to the component of a container for induction heating cookers which was mentioned above etc., sufficient effectiveness can be acquired.

[0006]

[Problem(s) to be Solved by the Invention] Although using the clad plate of a magnetic metallic material, and

the aluminum which is excellent in thermal conductivity and its alloy has been examined in the conventional container for induction heating cookers in order to raise the heating effectiveness by the electromagnetic wave as mentioned above. Since the deformation resistance between these ingredients differed greatly, there was a problem which a form status change form, exfoliation by the junction interface, etc. produce and burn at the time of processing of reducing conversely the thermal efficiency of the container for induction heating cookers by these.

[0007] This invention aims at offering the compound metallic material which was made in order to cope with such a technical problem, was made to stick enough between the metallic materials of a different kind with which deformation resistance etc. differs, and aimed at improvement in bonding strength, and its manufacture approach, and aims at offering the container for induction heating cookers which aimed at improvement in thermal efficiency or dependability further.

[0008]

[Means for Solving the Problem and its Function] The 1st compound metallic materials in this invention differ. It is the compound metallic material which carried out the laminating, and two sorts of metallic materials are described above. It is characterized by providing the porous interlayer by whom laminating fixing was done in said one metallic material, and said some of metallic materials of another side containing in said interlayer among two sorts of metallic materials.

[0009] The 1st manufacture approaches differ among the manufacture approaches of the compound metallic material the above 1st. In manufacturing the compound metallic material which carried out the laminating of two sorts of metallic materials It is characterized by having the process which joins this metallic material and the ingredient which has compatibility at least, and forms a porous interlayer on said one metallic material, and the process which carries out the laminating of the metallic material of said another side to one [said] metallic material, sinking in said metallic material of another side into said porous interlayer. Moreover, the 2nd manufacture approaches differ. The process which in manufacturing the compound metallic material which carried out the laminating of two sorts of metallic materials carries out thermal spraying of this metallic material and the ingredient which has compatibility at least, and forms a porous interlayer on said one metallic material, It is characterized by having the process which carries out the laminating of the metallic material of said another side to one [said] metallic material, sinking in said metallic material of another side into said porous interlayer.

[0010] Furthermore, the 3rd manufacture approaches differ. In manufacturing the compound metallic material which carried out the laminating of two sorts of metallic materials The process which carries out electrochemical membrane formation of this metallic material and the ingredient which has compatibility at least, and forms a porous interlayer on said one metallic material, It is characterized by having the process which carries out the laminating of the metallic material of said another side to one [said] metallic material, sinking in said metallic material of another side into said porous interlayer.

[0011] The 2nd compound metallic material in this invention is a compound metallic material which carried out the laminating of a magnetic metallic material and the high temperature conductivity metallic material, and is characterized by preparing the presentation inclined layer as an interlayer between said magnetic metallic material and a high temperature conductivity metallic material.

[0012] In the manufacture approach of the compound metallic material the above 2nd manufacturing the compound metallic material which carried out the laminating of a magnetic metallic material and the high temperature conductivity metallic material The process which forms the porous layer which contains said magnetic metallic material at least on said magnetic metallic material or its preforming object, It is characterized by having the process which carries out the laminating of said high temperature conductivity metallic material to said magnetic metallic material, sinking in said high temperature conductivity metallic material into said porous layer, and forming the presentation inclined layer of said magnetic metallic material and a high temperature conductivity metallic material.

[0013] Furthermore, the container for induction heating cookers of this invention is characterized by a pars basilaris ossis occipitalis consisting of the 1st compound metallic material of this invention, or the 2nd compound metallic material at least.

[0014] First, the 1st compound metallic material in this invention is described. it uses for the 1st compound metallic material as two sorts of metallic materials, although a magnetic metallic material and a highly

thermally-conductive material are illustrated, for example, it is not limited to these -- it is applicable to the dissimilar material which the diffusion rate between two sorts of metallic materials is slow, and cannot carry out an interface reaction easily. Electrical resistivity as the above-mentioned magnetic metallic material The thing more than 5.0micro ohm-cm (20 degrees C) is desirable, for example, iron and its alloy, various steel materials, nickel, its alloy, etc. are illustrated. Moreover, as a highly thermally-conductive material, the thing more than 120 W/m K (273-473K) has desirable thermal conductivity, for example, aluminum, aluminum alloy, etc. are illustrated.

[0015] the 1st compound metallic material forms in the front face of one metallic material the porous interlayer by whom laminating fixing was done, and some metallic materials of another side are made to contain in a porous interlayer -- acquiring the wedge effectiveness, while expanding the plane-of-composition product between two kinds of metallic materials -- adhesion and bond strength -- improvement in heat transfer effectiveness is aimed at further.

[0016] For example, the plane-of-composition product of the 1st metallic material 2 and the 2nd metallic material 3 using the porous interlayer 1 who has the wedge effectiveness shown in drawing 1 (a), If the plane-of-composition product of the 1st metallic material 4 and the 2nd metallic material 5 which have honing side 4a for the conventional general plane-of-composition product expansion shown in drawing 2 (a) is measured x in drawing 1 (b) and drawing 2 (b) At honing side 4a shown in drawing 2 when referred to as 1, a plane-of-composition product is abbreviation. As opposed to increasing only 1.4 times At the porous interlayer 1 who he wants to show drawing 1 and has the rust effectiveness, it is abbreviation. It increases by 5.2 times and increases in proportion to the porous interlayer's 1 thickness further. thus -- while the porous interlayer 1 and the 2nd metallic material 3 contained in the interior are intricately engaged to the **** direction (an arrow head A shows among drawing), namely, demonstrating the wedge effectiveness and obtaining high bonding strength -- a plane-of-composition product -- large -- expanding -- improvement in adhesion, and stress relaxation and **** prevention of a crack -- improvement in heat transfer effectiveness can be aimed at further.

[0017] The porous interlayer in the 1st compound metallic material of this invention is a laminating fixing layer of the ingredient (it is hereafter described as an interlayer component) which has one [at least] metallic material and compatibility, i.e., good affinity, reactivity, etc., and has the property of coefficient of thermal expansion approximating further. As an example of an interlayer component, if a metallic material is stainless steel, for example, ** material, an iron system ingredient, etc. will be illustrated.

[0018] Especially the concrete configuration of the above-mentioned interlayer component is not limited, and the Plastic solids using [for example,] powder, a granule, fiber, a wire, and they, such as a network and porosity preforming like a sponge metal, etc. are mentioned. Moreover, although especially the magnitude of these interlayer component is not limited, either, in the case of powder, a granule, fiber, etc., the diameter, for example 1-5000 micrometers It is desirable that it is extent. If these range is exceeded, sufficient wedge effectiveness will stop being able to obtain all easily. More desirable diameter Five to 500 micrometer It is the range and is ten to 200 micrometer still more preferably. It is the range. Moreover, when using a wire, a network, etc. as an interlayer component, it is not limited to the above-mentioned diameter range, and is set up according to a combination configuration, a fixing condition, etc.

[0019] Moreover, as an interlayer component, the mixture of one metallic material, the ingredient which has good compatibility, and the metallic material of another side and the ingredient which has good compatibility etc. can also be used. When the difference of the coefficient of thermal expansion between two kinds of metallic materials is large, an ingredient which eases this differential thermal expansion can also be chosen, and, thereby, stress relaxation can be planned. Furthermore, in order to control a coefficient of thermal expansion, porosity, etc., it is also possible to use the ingredient which mixed the ceramic ingredient etc.

[0020] As an approach of carrying out laminating fixing of the porous interlayer who consists of an interlayer component which was mentioned above at one metallic material, a conjugation method, a spraying process, the electrochemical forming-membranes method, etc. are illustrated. As the above-mentioned conjugation method, various kinds of junction approaches, such as baking junction of solid phase diffusion welding, welding (partial welding is included), etc., soldering, welding, and energization welding, are applicable. For example, baking junction is carried out by calcinating these, after forming a porosity application layer, a porosity pressing layer, etc. of the above-mentioned interlayer component in the front face of the metallic material which is going to join a porous interlayer or carrying out the laminating of the porosity Plastic solid by the interlayer component.

Moreover, generally as metal spraying, the flame-spraying method, the plasma metal spray method, etc. are learned, and unless special processing is performed since the layer with which the metal particles which became flat by spraying the particle of the metal fused at the elevated temperature lapped is obtained also when it is any, a porous metal layer is obtained. However, since, as for the bond strength of the thermal-spraying-ed object (metallic material) only in a condition and thermal-spraying layer (porous interlayer) which carried out thermal spraying, an oxidizing zone is generally generated by the interface, it becomes it is small and main mechanical becoming metallic association of a diffusion reaction etc. entangled according to the irregularity of an interface. Although the bond strength only by thermal spraying may be enough, when still bigger bond strength is required depending on the application and configuration of a compound metallic material, by heating to an elevated temperature to which an oxide film evaporates for example, in a vacuum, the interface of a thermal-spraying-ed object and a thermal-spraying layer can be activated, and bond strength can be increased.

[0021] Selecting a spray condition which increases the amount of supply of a thermal spray material which enlarges distance of the thermal spraying gun and thermal-spraying-ed object from which a low-temperature field is chosen as an approach of raising the porosity of the porous interlayer by the spraying process mentioned above etc. is illustrated. Furthermore, as a thermal spray material, the charge of an admixture can also be used for not only a metal but a metal, the ceramics, etc. The reaction control at the time of carrying out the laminating of the metallic material of coefficient of thermal expansion and porosity of the porous interlayer who consists of a thermal-spraying layer, thermal conductivity, and another side etc. is controllable by such composite spraying.

[0022] Furthermore, as an electrochemical forming-membranes method, an electrodeposition process, porosity plating, discharge coating, etc. are illustrated, and a porous interlayer can be obtained like the spraying process mentioned above also by these. Moreover, it is also possible to heat-treat, after performing electrochemical membrane formation, and to raise the bond strength of the film (porous interlayer) and a metallic material.

[0023] Moreover, considering as a porosity condition is important and the porous interlayer in this invention is specifically the rate of the volume of an interlayer component. It is desirable to consider as extent (porosity = 35 - 95%) 5 to 65%. sufficient reinforcement (bond strength) with the metallic material which carries out laminating fixing to the rate of the volume being less than 5% obtains -- having -- hard -- moreover -- If it exceeds 65%, the amount of sinking in of the metallic material of another side will decrease, and there is a possibility that the expansion effectiveness, the wedge effectiveness, etc. of a plane-of-composition product cannot fully be acquired. The more desirable rate of the volume is 20 - 60%, and is 25 - 55% still more preferably. Furthermore, the rate of the volume may be decreased towards the metallic material side of another side from a metallic material side, and while an inclination, i.e., a porous interlayer, is formed in the rate of the volume of the above-mentioned interlayer component (porosity) may make the metallic material of another side contain according to a volume inclination. Stress relaxation can be planned by considering as such a configuration.

[0024] The porous interlayer who made the rate of the volume of an interlayer component which was mentioned above incline is produced as follows, for example. namely, -- first -- an interlayer component and an organic material particle -- mixing -- the mixing ratio -- a rate -- for example, -- Two or more mixed powder changed in 5 - 30% of range is prepared. After carrying out a laminating one by one on one metallic material from mixed powder with the smallest mixing ratio of an organic material particle, the porous interlayer who made the rate of the volume (porosity) incline is formed by heating in a vacuum, vanishing an organic material particle. As an organic material to be used, the amorphism nature which is easy to disappear with heating, and a thermoplastic organic material are suitable, and styrene resin, vinyl chloride resin, acrylic resin, etc. are specifically illustrated. If the metallic material of another side is infiltrated into the porous interlayer who made a rate of the volume which was described above incline, the presentation inclination middle compound layer of the metallic material of another side and an interlayer component will be formed, a gradual change of a coefficient of thermal expansion can be brought about, and it will become possible to aim at relaxation of thermal stress.

[0025] Although the effectiveness (the plane-of-composition product expansion effectiveness, the wedge effectiveness, etc.) can be acquired and it is not especially limited, if it has combined with one metallic material firmly even if a porous interlayer's thickness which was mentioned above is a powdered monolayer printing layer etc., when acquiring the stable effectiveness 1-1000 micrometers Considering as extent is desirable. A more desirable interlayer's thickness is five to 500 micrometer. It is the range and is 50 to 150 micrometer still

more preferably. It is the range. However, as for an interlayer's thickness, it is desirable to set up according to the class and configuration of an interlayer component.

[0026] A laminating is carried out in the 1st compound metallic material of this invention, making some metallic materials of another side contain in the porous interlayer who mentioned above. The approach of infiltrating the molten metal of the metallic material concerned as an approach of making the metallic material of another side containing, into a porous interlayer, and the approach of heating and infiltrating, after being filled up with the powder of the metallic material concerned are illustrated. According to these sinking-in methods, the metallic material part of another side can be formed in coincidence.

[0027] As the above-mentioned molten metal sinking-in method, pressurization sinking in (liquid metal forging), dies casting, low pressure casting, centrifugal pressure casting, etc. are applicable. Moreover, as an approach using powder, liquid phase sintering, powder forging, a hotpress, etc. are mentioned. Especially, according to the molten metal pressurization sinking-in method, the metallic material of another side can be made to fully permeate to the interior of a porous interlayer, and good adhesion can be acquired easily, and sintering temperature differs. The metallic material whose number is two can be compound-ized good.

[0028] Next, the 2nd compound metallic material in this invention is described. The 2nd compound metallic material aims at improvement in bonding strength and adhesion by preparing a presentation inclined layer as an interlayer between a magnetic metallic material and a high temperature conductivity metallic material, and planning stress relaxation between these ingredients. In addition, the thing same as a magnetic metallic material and a high temperature conductivity metallic material as the 1st compound metallic material mentioned above is illustrated. The above-mentioned presentation inclined layer is a degree. It can divide roughly into two.

[0029] (1) The mixolimnion of a magnetic metallic material and a high temperature conductivity metallic material constitutes a presentation inclined layer, and consider as the mixolimnion which made the monolayer mixolimnion or the rate of a volume ratio incline.

[0030] (2) the mixolimnion of a magnetic metallic material, a high temperature conductivity metallic material, and a ceramic nominal member -- a presentation inclined layer -- constituting -- the inside of a mixolimnion -- make the rate of a volume ratio of a magnetic metallic material and a ceramic nominal member incline at least, and change a coefficient of thermal expansion gradually. Under the present circumstances, it is not necessary to make the rate of the volume of a high temperature conductivity metallic material not necessarily incline.

[0031] Above As a presentation inclined layer by (1), it is . It is desirable to consider as the layer to which the effectiveness could be acquired when it had the mixolimnion of the magnetic metallic material of one layer and a high temperature conductivity metallic material, and the presentation was further changed from the magnetic metallic material continuously or gradually towards the high temperature conductivity metallic material.

Especially the thickness of a presentation inclined layer is 1-1000 micrometers, although not limited.

Considering as extent is desirable. Moreover, as the 1st compound metallic material mentioned above explained, it is also possible to form a presentation inclined layer by forming as an interlayer the porous layer to which the rate of a volume ratio of a magnetic metallic material was changed, and sinking a high temperature conductivity metallic material into this interlayer. The manufacture approach of a porous layer of having changed the rate of a volume ratio of a magnetic metallic material is as having mentioned above.

[0032] Moreover, the above The presentation inclined layer by (2) is as being chosen out of for example, ceramic powder and ceramic fiber as it is few. One sort is added as a presentation inclination nominal member (ceramic nominal member), and the rate of a volume ratio of this ceramic nominal member and a magnetic metallic material is made to incline at least. Ceramic nominal members, such as ceramic powder and ceramic fiber, contribute also to the improvement in on the strength (dispersion strengthening) while contributing to relaxation of the differential thermal expansion between a magnetic metallic material and a high temperature conductivity metallic material. Therefore, ceramic nominal member It is also possible to add as improvement material in on the strength of the presentation inclined layer of (1).

[0033] As the quality of the material of ceramic powder which was mentioned above, or fiber, an oxide, a nitride, carbide, or these compound ghosts, such as aluminum, Si, Ti, Zr, Ta, and Cr, etc. are illustrated, for example. For the ceramic powder and fiber to be used, the diameter is 0.05 to 500 micrometer. What is extent is desirable. Moreover, as a content of ceramic powder or fiber, although it changes with thickness, classes, etc. of presentation inclined layer, the whole presentation inclined layer product is received. It is desirable to consider as the range of 5 - 50 volume % .

[0034] The 2nd compound metallic material which was mentioned above is the following, and making and manufacturing is desirable.

[0035] That is, the porous layer which contains a magnetic metallic material at least is formed by cold compression molding etc. on the plate of a magnetic metallic material, or its preforming object. As a preforming object of a magnetic metallic material, the powder-compacting Plastic solid of magnetic metallic material powder etc. is illustrated. Although there is especially no limit, a consistency the consistency of this powder-compacting Plastic solid Since for example, electromagnetic-induction heating effectiveness becomes it low that it is less than 80%, considering as 80% or more is desirable.

[0036] The above-mentioned porous layer may turn into a presentation inclined layer, and may make a high temperature conductivity metallic material contain beforehand. This high temperature conductivity metallic material made to contain beforehand is contributed to an improvement of a cold compression porous layer (preforming object) on the strength. Moreover, in forming the presentation inclined layer to which the presentation was changed gradually, it produces the multilayer structure to which the presentation of a magnetic metallic material was changed at least in the formation phase of a porous layer. Furthermore, in making a ceramic nominal member contain and forming a presentation inclined layer, it forms the porous layer of the multilayer structure to which the mixing ratio of a magnetic metallic material and a ceramic nominal member was changed.

[0037] Above In the case of the presentation inclined layer by (1), the presentation ratio of the high temperature conductivity metallic material in a presentation inclined layer is fundamentally determined by the void of a porous layer. Therefore, the rate of the volume of a porous layer is determined according to the presentation of the set-up presentation inclined layer. Such a rate of the volume of a porous layer takes into consideration the reinforcement of a porous layer, and the impregnating ability of a high temperature conductivity metallic material molten metal, and is 10 - 60%. Considering as extent is desirable. Moreover, the above Since, as for the presentation inclined layer by (2), a presentation inclination condition (change condition of a coefficient of thermal expansion) is fundamentally determined by the mixing ratio of a magnetic metallic material and a ceramic nominal member, it is not necessary to not necessarily change the rate of the volume of a porous layer (porosity). The rate of the volume of a porous layer is as having mentioned above.

[0038] And a high temperature conductivity metallic material is sunk in into the above-mentioned porous layer, and the laminating of the high temperature conductivity metallic material is carried out on a magnetic metallic material, forming a presentation inclined layer. As explained by the manufacture approach of the 1st compound metallic material mentioned above as a method of sinking in a metallic material, the approach of infiltrating the molten metal of the metallic material concerned, the approach of heating and infiltrating, after being filled up with the powder of the metallic material concerned, etc. are applicable. Thus, the target compound metallic material is obtained. While being able to make a high temperature conductivity metallic material fully permeate to the interior of the porous layer used as a presentation inclined layer and being able to obtain a good presentation inclined layer easily according to the molten metal pressurization sinking-in method especially among the above-mentioned sinking-in methods, deformation resistance differs from sintering temperature etc. Two kinds of metallic materials can be compound-ized good.

[0039] The container for induction heating cookers of this invention is constituted from the 1st compound metallic material of this invention or the 2nd compound metallic material which mentioned above the container pars basilaris ossis occipitalis at least, and a magnetic metallic material is arranged fundamentally at a periphery side. Since the stress which is excellent in bonding strength and originates in the differential thermal expansion between dissimilar metal ingredients is eased while excelling in adhesion, as mentioned above, the compound metallic material of this invention has very few possibilities of causing interfacial peeling etc., when a thermal shock is impressed. Moreover, heat transfer effectiveness can be further raised by expansion of a plane-of-composition product. Therefore, it becomes possible to raise sharply the thermal efficiency and dependability of the container for induction heating cookers.

[0040]

[Example] Hereafter, the example of this invention is explained.

[0041] an example 1 -- first -- as the 1st metallic material (magnetic material) -- the diameter of 10mm, and height of 15mm 1 % of the weight A silicon steel cylinder (electrical resistivity = 25micro ohm-cm) is prepared. It is mean particle diameter as an interlayer component on [after installing this in the metal mold of this

diameter] it. 100 micrometers It is filled up with pure iron powder and is thickness. 1mm, rate of the volume It fabricated so that it might become 50% of powder-compacting layer. Subsequently, it is in the vacuum of 1.33×10 to 2 Pa about this powder-compacting layer. 1373K It calcinated for 2 hours and the interlayer of the porosity condition joined by the silicon steel cylinder upper limit side was formed.

[0042] Next, it arranges in the metal mold of liquid metal forging which carried out the preheating of the silicon steel cylinder which has the above-mentioned porous interlayer to 673K, and is in this metal mold. aluminum alloy (6061, thermal conductivity = 167 W/m K) molten metal of 1053K is poured in, and it is aluminum alloy molten metal in a porous interlayer. aluminum alloy layer with a thickness of 15mm was formed as the 2nd metallic material (highly thermally-conductive material), carrying out pressurization sinking in by the pressure of 98MPa.

[0043] Thus, it is the following, and the tensile strength of the obtained compound metallic material was made and measured. First, die length of 30mm from the above-mentioned composite material, the diameter during the gage mark By 5mm, the interlayer produced the piece of a tensile test located in the center during the gage mark, and performed the tension test using this test piece. Consequently, the good value of 196MPa(s) in tensile strength was acquired, and the fracture location was between aluminum alloy layer and the interlayer.

[0044] It is mean particle diameter as an interlayer component on [after preparing the cylinder made from stainless steel (SUS430) (electrical resistivity = 60micro ohm-cm) with a diameter / of 10mm /, and a height of 15mm as the example 2 1st metallic material and installing this in the metal mold of this diameter] it. 100 micrometers It is filled up with stainless steel (SUS430) powder, and they are 0.25mm of thickness, and a rate of the volume. It fabricated so that it might become 65% of powder-compacting layer. Subsequently, it is in the vacuum of 1.33×10 to 2 Pa about this powder-compacting layer. 1373K It calcinated for 2 hours and the interlayer of the porosity condition joined by the cylinder upper limit side made from stainless steel was formed.

[0045] Next, it arranges in the metal mold of liquid metal forging which carried out the preheating of the cylinder made from stainless steel which has the above-mentioned porous interlayer to 673K, and is in this metal mold. aluminum alloy of 1053K (ADC12, thermal conductivity = 96 W/m K) A molten metal is poured in and it is aluminum alloy molten metal in a porous interlayer. aluminum alloy layer with a thickness of 15mm was formed as the 2nd metallic material, carrying out pressurization sinking in by the pressure of 98MPa.

[0046] Thus, when the test piece for tensile test was produced like the example 1 from the obtained compound metallic material and the tension test was carried out, the good value of 206MPa(s) in tensile strength was acquired, and the fracture location was between aluminum alloy layer and the interlayer.

[0047] Moreover, it gazed at the organization near the junction interface of the above-mentioned compound metallic material with the scanning electron microscope. As the result, the scanning electron microscope photograph near the junction interface is shown in drawing 3 . In addition, drawing 3 (a) is an enlargement near [including an interlayer] the junction interface (scale factor: 200 times), and drawing 3 (b) is the electron microscope photograph to which the inside of the interlayer was expanded further (scale factor: 1000 time). While aluminum alloy which is the 2nd metallic material invades in a porous interlayer and the plane-of-composition product is sharply expanded so that clearly from these photographs, it turns out that the good wedge effectiveness is acquired. Moreover, the adhesion of aluminum alloy and a porous interlayer is also known by that it is good.

[0048] After preparing the cylinder made of pure iron with a diameter [of 10mm], and a height of 15mm (electrical resistivity = 9.8micro ohm-cm) as the example 3 1st metallic material and installing this in the metal mold of this diameter, on it as an interlayer component Mean particle diameter 100 micrometers Pure iron powder and average diameter 3 micrometers Average die length It is filled up with mixture with a 3mm alumina fiber, and is thickness. 1mm, rate of the volume It fabricated so that it might become 35% (the rate of the volume of rate = of volume 15% of pure iron powder, and an alumina fiber = 20%) of powder fiber mixolimnion. Subsequently, it is in the vacuum of 1.33×10 to 2 Pa about this powder fiber mixing shaping layer. 1373K It calcinated for 2 hours and the interlayer of the porosity condition joined by the cylinder upper limit side made of pure iron was formed.

[0049] Next, it arranges in the metal mold of liquid metal forging which carried out the preheating of the cylinder made of pure iron which has the above-mentioned porous interlayer to 673K, and is in this metal mold. aluminum alloy (AC8B, thermal conductivity = 117 W/m K) molten metal of 1053K is poured in, and it is

aluminum alloy molten metal in a porous interlayer. aluminum alloy layer with a thickness of 15mm was formed as the 2nd metallic material, carrying out pressurization sinking in by the pressure of 98MPa.

[0050] Thus, when the test piece for tensile test was produced like the example 1 from the obtained compound metallic material and the tension test was carried out, the good value of 226MPa(s) in tensile strength was acquired, and the fracture location was between aluminum alloy layer and the interlayer.

[0051] After preparing the cylinder made of pure iron with a diameter [of 10mm], and a height of 15mm as the example 4 1st metallic material and installing this in the metal mold of this diameter, on it as an interlayer component Mean particle diameter of 10 micrometers Pure iron powder and 0.05 to 1.5 micrometer diameter Aspect ratios 20-200 It is filled up with mixture with a SiC whisker. Thickness 1mm, rate of the volume It fabricated so that it might become 25% (the rate of the volume of rate = of volume 10% of pure iron powder, and a SiC whisker = 15%) of powder fiber mixolinnion. Subsequently, it is in the vacuum of 1.33×10^{-2} to 2 Pa about this powder fiber mixing shaping layer. 1373K It calcinated for 2 hours and the interlayer of the porosity condition joined by the cylinder upper limit side made of pure iron was formed.

[0052] Next, it arranges in the metal mold of liquid metal forging which carried out the preheating of the cylinder made of pure iron which has the above-mentioned porous interlayer to 673K, and is in this metal mold. aluminum alloy (4032 thermal conductivity = 146W/m K) molten metal of 1053K is poured in, and it is aluminum alloy molten metal in a porous interlayer. aluminum alloy layer with a thickness of 15mm was formed as the 2nd metallic material, carrying out pressurization sinking in by the pressure of 98MPa.

[0053] Thus, when the test piece for tensile test was produced like the example 1 from the obtained compound metallic material and the tension test was carried out, the good value of 245MPa(s) in tensile strength was acquired, and the fracture location was between aluminum alloy layer and the interlayer.

[0054] 10 micrometers of mean diameters which the cylinder made of pure iron with a diameter [of 10mm] and a height of 15mm is prepared as the example 5 1st metallic material, and are a middle class component at the end face of this cylinder made of pure iron What mixed pure iron powder with the organic system binder is sprayed, and it is 10 micrometers of thickness. The powder application layer of 5% of rates of the volume was formed. Subsequently, it is in the vacuum of 1.33×10^{-2} to 2 Pa about this powder application layer. 1373K It calcinated for 2 hours and the interlayer of the porosity condition joined by the cylinder upper limit side made of pure iron was formed.

[0055] Next, it arranges in the metal mold of liquid metal forging which carried out the preheating of the cylinder made of pure iron which has the above-mentioned porous interlayer to 673K, and is in this metal mold. aluminum alloy (1200 thermal conductivity = 218W/m K) molten metal of 1053K is poured in, and it is aluminum alloy molten metal in a porous interlayer. aluminum alloy layer with a thickness of 15mm was formed as the 2nd metallic material, carrying out pressurization sinking in by the pressure of 98MPa.

[0056] Thus, when the test piece for tensile test was produced like the example 1 from the obtained compound metallic material and the tension test was carried out, the good value of 167MPa(s) in tensile strength was acquired, and the fracture location was between aluminum alloy layer and the interlayer.

[0057] It is a diameter as the example 6 1st metallic material. 250mm, thickness The disk made from stainless steel (SUS430) (electrical resistivity = 60micro ohm-cm) of 0.6 to 1.0 mm is prepared. After carrying out thermal spraying of each thermal-spraying material shown in Table 1 to the front face of this disk made from stainless steel according to the spray condition shown in Table 1, respectively, Vacuum diffusion heat treatment was performed under conditions of 1253 - 1473Kx 2 hours in the vacuum of 1.33×10^{-2} to 1.33×10^{-4} Pa, and the porous interlayer was obtained, respectively.

[0058] Next, aluminum layer was formed as the 2nd metallic material, having arranged the disk made from stainless steel which has the various above-mentioned porous interlayers in the metal mold of liquid metal forging which carried out the preheating to 673K, respectively, having poured in aluminum molten metal of 1023-1073K into this metal mold, and carrying out pressurization sinking in of the aluminum molten metal by the pressure of 40- 98MPa into a porous interlayer. In addition, it was performed, cooling maintaining a pressurization condition.

[0059] Thus, the test piece for tensile test was produced like the example 1 from each obtained compound metallic material, and the tension test was carried out. The result is collectively shown in Table 1. Moreover, even if it burned underwater after heating each compound metallic material to 673K, it did not exfoliate with the impact.

[Table 1]

試料 No	溶射材	溶射法 (熱源)	溶射距離 (mm)	溶射層の 厚さ (μm)	溶射層の 気孔率 (%)	引張強度 (MPa)
1	SUS 430	プラズマ	150	50	15	230
2	Ni	アーク	250	150	16	245
3	鉄	火炎	300	200	26	240
4	SUS 430	プラズマ	150	80	12	175
5	Cu	火炎	350	150	30	250
6	Ni + アルミナ	プラズマ	150	100	32	255

*: 体積率は 1:1

They are the diameter of 10mm, and thickness as the example 7 1st metallic material. The 150mm cylinder made from stainless steel (SUS430) (electrical resistivity = 60micro ohm-cm) is prepared, nickel plating explained in full detail below on the front face of this cylinder made from stainless steel and compound plating by the electrophoretic deposition of an alumina particle are performed, and they are 40 micrometers of thickness, and a rate of the volume. The porous interlayer by 75% of electrochemical membrane formation layer was obtained.

[0060] Compound plating was performed by [as being the following]. First, nickel-sulfate 150 g/l, a nickel chloride 15 g/l, boric acid nickel plating liquid (pH=6) containing 15 g/l is prepared, and it is the mean particle diameter of 10 micrometers to this. The alumina particle was mixed at a rate of 200g/l. Into this plating liquid, the above-mentioned cylinder made from stainless steel is inserted as cathode, and it is current density. 3 A/dm² It plated. Thereby, an alumina particle is a rate of the volume in nickel deposit. It is contained at 10% of a rate, and porosity is 25%. The porous compound layer was obtained. It is in the vacuum of 1.33x10 to 3 Pa to this porous compound layer. Diffusion process was performed on the conditions of 1373 Kx5 hours, and it considered as the porous interlayer.

[0061] Next, it arranges in the metal mold of liquid metal forging which carried out the preheating of the cylinder made from stainless steel which has a porous interlayer by the above-mentioned electrochemical membrane formation to 673K, and is in this metal mold. aluminum alloy (6061, thermal conductivity =167 W/m K) molten metal of 1053K is poured in, and it is aluminum alloy molten metal in a porous interlayer. aluminum alloy layer with a thickness of 15mm was formed as the 2nd metallic material (highly thermally-conductive material), carrying out pressurization sinking in by the pressure of 98MPa.

[0062] Thus, when the test piece for tensile test was produced like the example 1 from the obtained compound metallic material and the tension test was carried out, the good value of 215MPa(s) in tensile strength was acquired, and the fracture location was between aluminum alloy layer and the interlayer.

[0063] an example 8 -- the cylinder made from stainless steel which has a porous interlayer was first produced like the example 2. Next, the cylinder made from stainless steel which has this porous interlayer has been arranged in metal mold, and a proper quantity of aluminum alloy (6061, thermal conductivity =167 W/m K) powder was introduced in this metal mold. 855K [subsequently,] which are the liquid phase temperature of the above-mentioned aluminum alloy about powder temperature in atmospheric air 50K -- the pressure of 40-58MPa after holding to 903K [high] -- upper metal mold -- in addition, aluminum alloy layer of 100% of consistencies was formed by 20mm in thickness as the 2nd metallic material. By it, the oxide film between initial particles can sink in aluminum alloy good into a porous interlayer while a Plastic solid with sufficient elongation is acquired by the pressurization under the temperature beyond the above-mentioned solution layer temperature, since it destroys.

[0064] Thus, when the test piece for tensile test was produced like the example 1 from the obtained compound metallic material and the tension test was carried out, the good value of 180MPa(s) in tensile strength was acquired, and the fracture location was between aluminum alloy layer and the interlayer. In addition, although powder forging was performed in atmospheric air in the above-mentioned example, a better result can be obtained by performing powder forging in a vacuum.

[0065] They are width of face of 10mm, and die length as the example 1st metallic material. 100mm, thickness 5mm nickel plate ($10.3\mu\text{ohm-cm}$) [Electrical resistivity =] Coefficient of thermal expansion = $13.4 \times 10^{-6}/\text{K}$ is prepared and it is the mean particle diameter of 40 micrometers to the front face of this nickel plate. Stainless steel (SUS304) powder (coefficient of thermal expansion = $17.3 \times 10^{-6}/\text{K}$), Diameter 1.0 micrometers Die length of 50 micrometers The SiC whisker (coefficient of thermal expansion = $3.2 \times 10^{-6}/\text{K}$) was mixed. Two kinds of mixture is applied in order, The porous layer of two-layer structure was formed. this -- the porous layer of two-layer structure -- first -- the front face of a nickel plate -- stainless steel (SUS304) powder 30 micrometers in thickness which set the weight ratio of a SiC whisker to 10:1 a porous layer -- forming -- further -- a it top -- stainless steel (SUS304) powder Weight ratio of a SiC whisker 30 micrometers in thickness set to 2.5:1 The porous layer was formed. each volume ratio -- about -- 4:1 It is 1:1. Subsequently, it is in the vacuum of 1.33×10 to 2 Pa like an example 1 about the porous layer of this two-layer structure. 1373K It calcinated for 2 hours.

[0066] Next, the above The nickel plate in which the porous layer of two-layer structure was formed is arranged in the metal mold of liquid metal forging which carried out the preheating to 673K. To the inside of this metal mold aluminum alloy of 1053K (AC8B, thermal conductivity = 117 W/m K) Coefficient of thermal expansion = $22 \times 10^{-6} / \text{K}$ molten metal is poured in, and it is aluminum alloy molten metal in a porous layer. It is thickness as the 2nd metallic material, carrying out pressurization sinking in by the pressure of 98MPa, and forming a presentation inclined layer. 5mm aluminum alloy layer was formed.

[0067] Thus, although the deformation resulting from the difference of a coefficient of thermal expansion was produced when it supplied to direct underwater and quenched, after heating the obtained compound metallic material to 723K, the crack etc. was not produced at all in a junction interface. In addition, it is 60 micrometers in thickness as an example of reference only in the end of iron powder. The porous layer was formed, and like the above-mentioned example, when it performed vacuum sintering and liquid-metal-forging sinking [of aluminum alloy] in, and the test piece was produced and same water quenching was performed, the crack arose in the interface of aluminum alloy layer and a porous layer.

[0068] They are width of face of 10mm, and die length as the example 10 1st metallic material. 100mm, thickness A 5mm stainless steel (SUS430) plate (electrical resistivity = $10.3\mu\text{ohm-cm}$ and coefficient-of-thermal-expansion = $13.4 \times 10^{-6}/\text{K}$) is prepared. It is the mean particle diameter of 10 micrometers first to the front face of this stainless plate. It is 50 micrometers in thickness about the end of iron powder. It applies so that it may become, and subsequently they are the above-mentioned end of iron powder, and the diameter of 40 micrometers. It is 50 micrometers in thickness about the powder which mixed the polystyrol particle (volume mixing ratio = 3:1). It applied so that it might become. Subsequently, it is in the vacuum of 1.33×10 to 2 Pa like an example 1. 1373K It decomposed and the polystyrol particle was vaporized at the same time it calcinated for 2 hours and performed diffused junction of comrades and the end of iron powder, and a stainless plate in the end of iron powder. In the location where the polystyrol particle existed, it is about 35 micrometers. The hole remained. The rate of the volume in the end of iron powder is abbreviation. 70% and abbreviation It became 55% and checked that the porous layer toward which the rate of a volume ratio inclined was formed.

[0069] Next, the stainless plate in which the porous layer which made the above-mentioned rate of a volume ratio incline was formed is arranged in the metal mold of liquid metal forging which carried out the preheating to 673K. inside [] of this metal mold -- aluminum alloy (AC8B and thermal conductivity = 117W/m K --) of 1053K Coefficient of thermal expansion = $22 \times 10^{-6} / \text{K}$ molten metal is poured in, and it is aluminum alloy molten metal in a porous layer. It is thickness as the 2nd metallic material, carrying out pressurization sinking in by the pressure of 98MPa, and forming a presentation inclined layer. 5mm aluminum alloy layer was formed.

[0070] Thus, although the deformation resulting from the difference of a coefficient of thermal expansion was produced when it supplied to direct underwater and quenched, after heating the obtained compound metallic material to 723K, the crack etc. was not produced at all in a junction interface. In addition, it is thickness as an example of reference only in the end of iron powder. 100 micrometers The porous layer was formed, and like the above-mentioned example, when it performed vacuum sintering and liquid-metal-forging sinking [of aluminum alloy] in, and the test piece was produced and same water quenching was performed, the crack arose in the interface of aluminum alloy layer and a porous layer.

[0071] It is granularity $R_{\text{max}} = 50\text{micrometer}$ about the end face of the cylinder made from S45C with a diameter [example of comparison 1 / of 10mm], and a height of 15mm. After carrying out honing so that it

may become, it installed in the metal mold of liquid metal forging of this diameter. To subsequently, the inside of this metal mold aluminum alloy (6061) molten metal of 1053K was poured in, and aluminum alloy layer with a thickness of 15mm was formed. It is tension strength, when the test piece for tensile test was produced like the example 1 from this compound metallic material and the tension test was carried out. Only less than 30 MPas and a low value were acquired.

[0072] It is granularity $R_{max} = 50$ micrometer about the end face of the cylinder made from stainless steel (SUS430) with a diameter [example of comparison 2 / of 10mm], and a height of 15mm. After performing photo etching so that it may become, it installed in the metal mold of liquid metal forging of this diameter. To subsequently, the inside of this metal mold aluminum alloy (6061) molten metal of 1053K was poured in, and aluminum alloy layer with a thickness of 15mm was formed. It is tension strength, when the test piece for tensile test was produced like the example 1 from this compound metallic material and the tension test was carried out. Only less than 35 MPas and a low value were acquired.

[0073] Next, the example of the container for induction heating cookers of this invention is described.

[0074] Example 11 diameter 250mm, thickness The 0.6mm disk made from stainless steel (SUS430) is prepared, and it is a mean diameter to the end face of this disk made from stainless steel. 100 micrometers What mixed pure iron powder with the organic system binder is sprayed, and it is thickness. The rate of the volume of 0.5mm and pure iron powder The powder application layer which is 15% was formed. Subsequently, it is in the vacuum of 1.33×10 to 2 Pa about this powder application layer. 1426K It calcinated for 2 hours and the interlayer of the porosity condition joined to the disk made from stainless steel was formed.

[0075] Next, the disk made from stainless steel which has a porous interlayer in the surface section is arranged at the pars basilaris ossis occipitalis of the metal mold of the container configuration for induction heating cookers which carried out the preheating to 673K, and it is in this metal mold for containers. aluminum alloy (ADC12) molten metal of 1073K is poured in, and it is aluminum alloy molten metal in a porous interlayer. The vessel wall produced the container for induction heating cookers (pan) which consists of an aluminum alloy, carrying out pressurization sinking in by the pressure of 98MPa. That is, as shown in drawing 4 , while constituting pars-basilaris-ossis-occipitalis 15a from a compound metallic material 14 which carried out laminating junction of the aluminum alloy layer 11 and the stainless steel layer 12 through the porous interlayer 13 who infiltrated aluminum alloy, the container 15 for induction heating cookers (pan) which constituted the other vessel-wall 15b from an aluminum alloy was obtained.

[0076] Thus, when the obtained pars basilaris ossis occipitalis performed the heat test of 1500 cc of water of 298K on the induction heating cooker using the container which consists of a compound metallic material, it boiled in 250 seconds. When the heat test was similarly performed as a comparison with this invention on the other hand using the container which constituted the pars basilaris ossis occipitalis from a clad plate of SUS430 and aluminum alloy (ADC12), it is ebullition. It took 320 seconds. Thus, in the container for induction heating cookers of this invention, since it excels in the dependability and heat transfer effectiveness of the junction interface while the good adhesion of a magnetic metallic material (SUS430) and a highly thermally-conductive material (aluminum alloy (ADC12)) is acquired, improvement in thermal efficiency can be aimed at.

[0077] Moreover, when the spalling test by heating and cooling from ordinary temperature to 823K was performed to the container for induction heating cookers of the above-mentioned example, exfoliation was not accepted in a junction interface etc. after 1000 heating and cooling, but it checked excelling in thermal shock nature. On the other hand, with the container by the above-mentioned example of a comparison, exfoliation occurred after 250 heating / cooling.

[0078] The container 15 for induction heating cookers (pan) was produced like the example 11, respectively except considering as the compound metallic material which produced pars-basilaris-ossis-occipitalis 15a of the container 15 for induction heating cookers in the example 12 above-mentioned example 11 (pan) at the same process as the examples 6 and 7 mentioned above. When the property of the container 15 for these induction heating cookers (pan) was similarly estimated as the example 11, the good result equivalent to an example 11 was obtained.

[0079] The container 15 for induction heating cookers (pan) was produced like the example 9 except producing the aluminum alloy layer 11 and vessel-wall 15b in pars-basilaris-ossis-occipitalis 15a of the container 15 for induction heating cookers in the example 13 above-mentioned example 11 (pan) at the same process as the example 8 mentioned above. When the property of this container 15 for induction heating cookers (pan) was

similarly estimated as the example 11, the good result equivalent to an example 11 was obtained.

[0080] Example 14 mean particle diameter 150 micrometers Diameter which carried out pressing of the stainless steel (SUS430) powder by the pressure of about 686 MPa(s) 200mm, thickness 1mm, consistency About 95% of Plastic solid, it is in the vacuum of 1.33×10^{-3} Pa. It sintered in 1473K and 1 hour, and the magnetic metal powder layer was produced. On this magnetic metal powder layer, the mixed powder layer of stainless steel (SUS430) powder and aluminum alloy (AC8C) powder was fabricated so that the rate of the volume might become 50% (the rate of the volume of rate = of volume 25% of stainless steel powder, and aluminum alloy = 25%). Thus, the preforming object of a magnetic metal layer and a presentation inclined layer was produced.

[0081] Next, the preforming object of the above-mentioned magnetic metal layer and a presentation inclined layer is arranged at the pars basilaris ossis occipitalis of the metal mold (diameter = 220mm) of the container configuration for induction heating cookers which carried out the preheating to 723K. It is 1073K in this metal mold for containers. It is aluminum alloy molten metal to the mixed powder-molding layer which pours in aluminum alloy (AC8C) molten metal, and turns into a presentation inclined layer. The vessel wall produced the container for induction heating cookers (pan) which consists of an aluminum alloy, carrying out pressurization sinking in by the pressure of 98MPa. That is, as shown in drawing 5, it is a volume ratio about aluminum alloy and stainless steel (SUS430) in the aluminum alloy layer 21 and the stainless steel layer 22. While constituting the pars basilaris ossis occipitalis from a compound metallic material 24 which carried out laminating junction through the presentation inclined layer 23 contained by 3:1, the container for induction heating cookers (pan) which constituted the other vessel wall from an aluminum alloy was obtained.

[0082] Thus, when the obtained pars basilaris ossis occipitalis performed the heat test of 1500 cc of water of 298K on the induction heating cooker using the container which consists of a compound metallic material, it boiled in 250 seconds. Moreover, when the spalling test by heating and cooling from ordinary temperature to 523K was performed, exfoliation was not accepted in a junction interface etc. after 1000 heating and cooling.

[0083] Example 15 mean particle diameter 150 micrometers Stainless steel (SUS430) powder is pressurized by the pressure of about 686 MPa(s), and it is a diameter. 200mm, thickness 1mm, consistency 95% of magnetic metal powder layer was produced. Subsequently, 60% (the rate of the volume of rate = of volume 50% of stainless steel powder and an alumina fiber = 10%) of the 1st layer and rate of the volume fabricated [the rate of the volume] 60% (the rate of the volume of rate = of volume 25% of stainless steel powder, and an alumina fiber = 35%) of the 2nd layer in order on the above-mentioned magnetic metal powder layer using the mixture of stainless steel (SUS430) powder and an alumina fiber. Thus, magnetic metal layer The preforming object with the presentation inclined layer of two-layer structure was produced.

[0084] Next, the above-mentioned magnetic metal layer A preforming object with the presentation inclined layer of two-layer structure It arranges at the pars basilaris ossis occipitalis of the metal mold (diameter = 220mm) of the container configuration for induction heating cookers which carried out the preheating to 723K. To the inside of this metal mold for containers 800-degree C aluminum alloy (AC8C) molten metal is poured in, and it becomes a presentation inclined layer. It is aluminum alloy molten metal to the mixture shaping layer of two-layer structure. The vessel wall produced the container for induction heating cookers (pan) which consists of an aluminum alloy, carrying out pressurization sinking in by the pressure of 98MPa. As shown in drawing 6, namely, the aluminum alloy layer 21 and the stainless steel layer 22 The presentation inclined layer 25 (the 1st layer 25a (stainless steel = 50%)) of two-layer structure aluminum alloy = 40%, an alumina fiber = while constituting a pars basilaris ossis occipitalis from a compound metallic material 26 which carried out laminating junction through 10% and 2nd layer 25b (the rate of stainless steel = 25%, aluminum alloy = 40%, and an alumina fiber = 35%) The container for induction heating cookers (pan) which constituted the other vessel wall from an aluminum alloy was obtained.

[0085] Thus, when the obtained pars basilaris ossis occipitalis performed the heat test of 1500 cc of water of 298K on the induction heating cooker using the container which consists of a compound metallic material, it boiled in 250 seconds. Moreover, when the spalling test by heating and cooling from ordinary temperature to 523K was performed, exfoliation was not accepted in a junction interface etc. after 1000 heating and cooling.

[0086]

[Effect of the Invention] As explained above, while sticking enough between the metallic materials of a different kind with which deformation resistance etc. differs according to this invention, it becomes possible to

offer the compound metallic material which the outstanding bonding strength was obtained and was excellent in the dependability of a junction interface. Therefore, it becomes possible by using such a compound metallic material to offer the container for induction heating cookers which raised thermal efficiency and dependability sharply.

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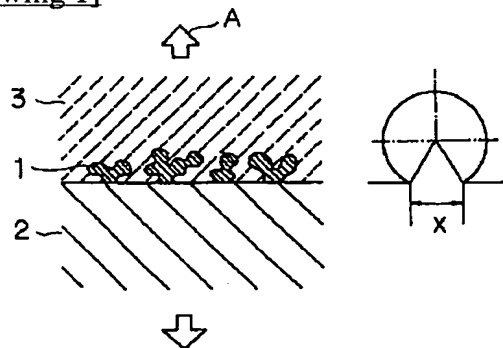
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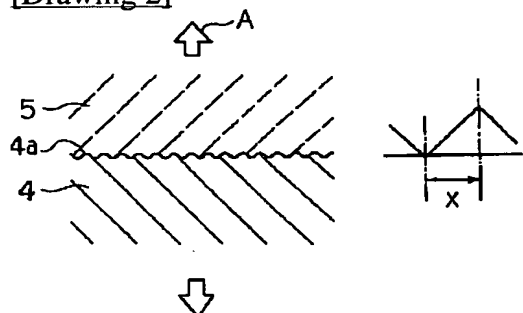
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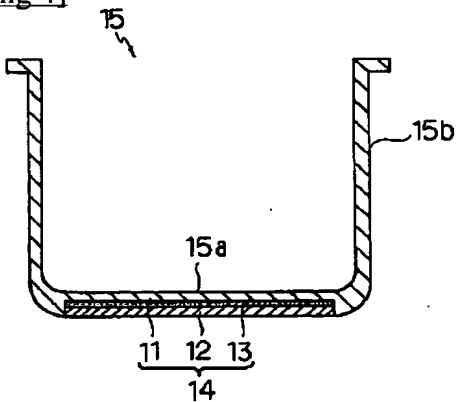
[Drawing 1]



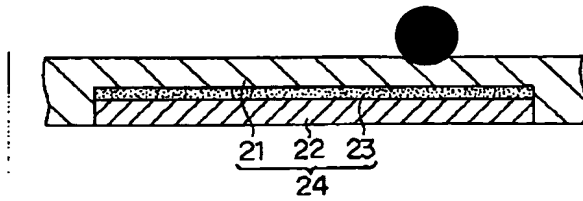
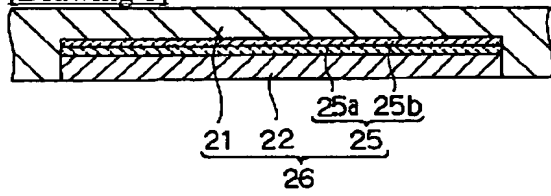
[Drawing 2]



[Drawing 4]



[Drawing 5]

[Drawing 6][Drawing 3]

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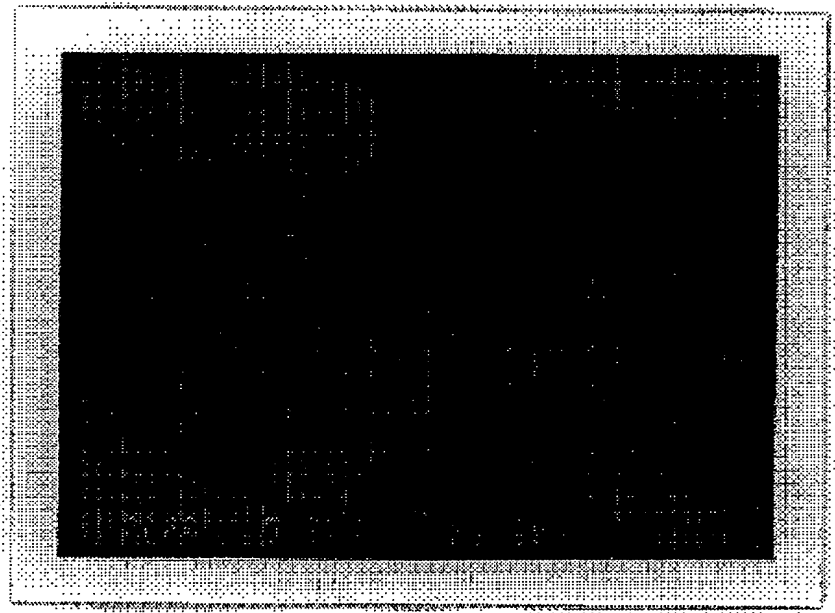
SUS430 | 中層 | ADC12

(a)



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(b)



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